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*1998*

**SUMMARY TECHNICAL  
REPORT**

**1998 NASA-ASEE-STANFORD  
SUMMER FACULTY FELLOWSHIP PROGRAM**

Ames Research Center  
Dryden Flight Research Center  
Stanford University

October 1998

**1998 NASA SUMMER FACULTY FELLOWSHIP PROGRAM**  
**TOPICS RESEARCHED AND REPORTED BY THE FELLOWS**

<b><u>Faculty Fellow &amp; (NASA Colleague/Division)</u></b>	<b><u>University Affiliation</u></b>	<b><u>Title of Research Project</u></b>
Assoc. Prof. Amanie Abdelmessih (1) (Tom Horn/RS)	Dept. of Mechanical Engr. Saint Martin's College	"Experimental Measurements of Temperature and Heat Flux in a High Temperature Black Body Cavity" <i>1</i>
Assoc. Prof. Cesar Compadre (1) (Muriel Ross/SL)	Dept. of Biopharmaceutical Sciences, University of Arkansas for Medical Sciences	"Virtual Reality Simulation of the Effects of Microgravity in Gastrointestinal Physiology" <i>2</i>
Assoc. Prof. Jane Friedman (2) (Michael Lowery/IC)	Dept. of Math. & Comp. Sci. University of San Diego	"Educational Applications on the World Wide Web: An Example Using Amphion" <i>3</i>
Professor Oswaldo Garcia (1) (R. Steve Hipskind/SGG)	Dept. of Meterology San Francisco State Univ.	"The Detection of Polar Stratospheric Clouds Using AVHRR Imagery" <i>4</i>
Assoc. Prof. Joel Henry (2) (Ann Patterson-Hine /IC)	Dept. of Comp. & Info. Sci. East Tennessee State Univ.	"Testing and Troubleshooting Embedded Real-Time Software" <i>5</i>
Asst. Prof. Paul Herrick (2) (Mike Arebalo/OE)	Dept. of Aviation Tech. Univ. of Alaska at Anchorage	"F18 Life Support - APECS and EDOX Cockpit Integration" <i>6</i>
Professor Stanley Herwitz (2) (Robert Slye/SG)	Grad. Sch. of Geography Clark University	"High Resolution Airborne Digital Imagery for Precision Agriculture" <i>7</i>
Assoc. Prof. Phil Kesten (2) (Yvonne Pendleton & Dale Cruikshak/SST)	Dept. of Physics Santa Clara University	"Photometric Study of Uranian Satellites" <i>8</i>
Asst. Prof. Gene Korienek (1) (Robert Welch/SL)	Dept. of Exercise & Sports Physiology Oregon State University	"The Mars Gravity Simulation Project" <i>9</i>
Professor Samaan Ladkany (2) (William Borucki & Robert Strawn/AAR)	Dept. of Civil Engineering Univ. of Nevada, Las Vegas	"Proposed Wind Turbine Aeroelasticity Studies Using Helicopter Systems Analysis" <i>10</i>
Asst. Prof. Michael Lambert (1) (Louis Salerno & Susan White/STM)	Dept. of Mechanical and Aerospace Engineering San Jose State University	"Measuring Thermal Conductivity and Moisture Absorption of Cryo-Insulation Materials" <i>11</i>
Asst. Prof. Michael Liang (2) (Sara Arnaud /SLR)	Sch. of HEPR - Kinesiology Bowling Green State Univ.	"High Salt Diets, Bone Strength and Mineral Content of Mature Femur After Skeletal Unloading" <i>12</i>

Assoc. Prof. Mary Sue Lowery (2) (Nancy Daunton/SL)	Dept. of Biology University of San Diego	"Investigations of the Effects of Altered Vestibular System Function on Hindlimb Anti-gravity Muscles" <i>-13</i>
Asst. Prof. Preston MacDougall (1) (Creon Levit/INA)	Dept. of Chemistry Middle Tennessee State Univ.	"A Synthesis of Fluid Dynamics and Quantum Chemistry for the Design of Nanoelectronics" <i>-14</i>
Asst. Prof. Jesse Maddren (2) (Frank Milo/STM)	Dept. of Mechanical and Aerospace Engineering San Jose State University	"Thermal Property Parameter Estimation of TPS Materials" <i>-15</i>
Assoc. Prof. Jose Mena-Werth (1) (William Borucki/SST)	Dept. of Physics & Phys. Sci. Univ. of Nebraska, Kearney	"The Dependence of Signal-to-Noise Ratio (S/N) Between Star Brightness and Background on the Filter Used in Images Taken by the Vulcan Photometric Planet-Search Camera" <i>-16</i>
Professor Ellen Metzger (2) (Geoff Briggs & Jack Marshall/SSX)	Dept. of Geology San Jose State University	"Use of Concept Mapping to Enhance and Update an Educational CD Rom About Mars" <i>-17</i>
Assoc. Prof. Richard Nemes (2) (John Lekashman/IN)	Dept. of Computer Science Pace University	"Distributed Queries of Large Numerical Data Sets" <i>-18</i>
Sandra Pizzarello, Ph.D. (1) (George Cooper & Sherwood Chang/SSX)	Dept. of Chemistry and Biochemistry Arizona State University	"Enantiometric Excesses of Acid Labile Amino Acid Precursors of the Murchison Meteorite" <i>-19</i>
Assoc. Prof. Stephen Pronchick (1) (Frank Milos/STM)	Dept. of Engineering and Technology California Maritime Academy	"An Integrated Tool for the Coupled Thermal and Mechanical Analysis of Pyrolyzing Heatshield Materials" <i>-20</i>
Asst. Prof. Scot Rafkin (1) (Robert Haberle/SST)	Dept. of Earth System Sci. and Policy Institute Calif. State Univ., Monterey Bay	"Application of the Regional Atmospheric Modeling System to the Martian Atmosphere" <i>-21</i>
Asst. Prof. Jeffrey Seitz (1) (Jay Skiles & Hector D'Antoni/SGE)	Dept. of Geological Sci. Calif. State Univ., Hayward	"Analysis of the UV-B Regime and Potential Effects on Alfalfa" <i>-22</i>
Professor Steven Senger (2) (Muriel Ross/SLR)	Dept. of Computer Science and Math University of Wisconsin - La Crosse	"User Directed Tools for Exploiting Expert Knowledge in an Immersive Segmentation and Visualization Environment" <i>-23</i>
Prof. Hamid Shahnasser (1) (Scott Santiago/Paul Grams/II)	Dept. of Electrical Engineering San Francisco State University	"Simulation of Ames Backbone Network" <i>-24</i>

Assoc. Prof. Daniel Sheehan (2) (Jeffrey Cuzzi/SST)	Dept. of Physics University of San Diego	"Rossby Waves in the Proplanetary Nebula"
Asst. Prof. Fredrick Sheldon (2) (Michael Lowery/IN)	Dept. of Computer Science University of Colorado	"Composing, Analyzing and Validating Software Models"
Assoc. Prof. Bradley Stone (1) (Louis Allamandola/SSA)	Dept. of Chemistry San Jose State University	"The Identification of Complex Organic Molecules in the Interstellar Medium: Using Lasers and Matrix Isolation Spectroscopy to Simulate the Interstellar Environment"
Professor Frieda Taub (2) (Ed Goolish/Charlie Wade /SLO)	School of Fisheries University of Washington	"Ecological Support of Larval Fish During Multigenerational Studies on Space Station"
Asst. Prof. Joel Thompson (1) (David DesMarais/SSX)	Dept.of Marine Sciences Eckerd College	"Textural and Carbon Isotopic Analyses of Modern Carbonate Microbialites: Possible Ancient and Martian Analogs"
Tom Tucker (1) (Dill Hunley /T)	Instructor, Technical Writing Isothermal Community College	"Harnessing the Brute: The Development of Propulsion- Controlled Aircraft at NASA Dryden"
Asst. Prof. Robin Ward (1) (Marianne McCarthy /T)	Dept. of Mathematics Calif. Polytechnic State Univ., San Luis Obispo	"Making the Learning of Mathematics Meaningful"

(1) Denotes First Year Fellow  
 (2) Denotes Second Year Fellow

## **PREFACE**

As is customary, the final technical report for the NASA-ASEE Summer Faculty Fellowship Program at the Ames Research Center, Dryden Flight Research Center and Stanford University essentially consists of a compilation of the summary technical reports of all the fellows. The reports are listed alphabetically by faculty fellow. More extended versions done either as NASA publications, archival papers, or other laboratory reports are not included here. The reader will note that the areas receiving emphasis were the life sciences, astronomy, remote sensing, aeronautics, fluid dynamics/aerophysics, and computer science. Of course, the areas of emphasis vary somewhat from year to year depending on the interests of the most qualified applicants. Once again, the work is of especially high quality.

Michael Tauber and Meredith Moore  
Co-Directors  
Summer Faculty Fellowship Program at  
Ames Research Center, Dryden Flight  
Research Center and Stanford University

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1998 NASA-ASEE-Dryden Flight Research Center  
Summer Faculty Research Fellowship  
Final Report

31.

Experimental Measurements of Temperature and Heat Flux in a  
High Temperature Black Body Cavity

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Amanie N. Abdelmessih, Ph. D.

Associate Professor

Mechanical Engineering Department  
Saint Martin's College, Lacey, WA

### Introduction

During hypersonic flight, high temperatures and high heat fluxes are generated. The Flight Loads Laboratory (FLL) at Dryden Flight Research Center (DFRC) is equipped to calibrate high heat fluxes up to  $1100 \text{ kW/m}^2$ . There are numerous uncertainties associated with these heat flux calibrations, as the process is transient, there are expected to be interactions between transient conduction, natural and forced convection, radiation, and possibly an insignificant degree of oxidation of the graphite cavity. Better understanding, of these mechanisms during the calibration process, will provide more reliable heat transfer data during either ground testing or flight testing of hypersonic vehicles.

### Experiments

A 25 mm variable temperature black body furnace, manufactured by Thermogage Inc. was used in the experiments. The black body is a graphite cylinder 28.9 cm long, with a 5 mm thick partition at the middle, as shown in Figure 1.

At the top center of the black body is an oval slot 9.4 mm x 3.1 mm. The graphite cylinder is resistance heated with copper electrodes connected to the copper end caps of the graphite cylinder. The end caps are water cooled. At 1100 °C and above the graphite cylinder was insulated on the outside with layers of graphite felt and grafoil tape. Graphite extension tubes, 15.2 cm, are connected to both end caps.

To avoid oxidation of the graphite to carbon dioxide, argon was used to purge inside and outside of the black body and was maintained at  $0.28 \text{ m}^3/\text{hr}$  through all the experiments. The furnace temperature is computer controlled. At one end of the black body cavity an optical pyrometer (used for control) was located. At the other end temperatures were taken with another optical pyrometer, laser pyrometer, and a bent optical fiber thermometer. Also Gardon heat flux gages, one with a window and the other without, were located at the later end.

We experimentally measured the temperatures, in the black body cavity, in the range of 800 °C to 1900 °C in increments of 100 °C. At each of these temperature increments, the heat fluxes were recorded. The optical and laser pyrometers measured the temperature of the center of the middle partition. The optical fiber pyrometer measured peripheral circumferential temperatures at 45° angles. Predetermined axial locations (14.2, 13.6, 12.9, 11.7, 9.1, 6.6, 4.06, 1.53, and 0.46 cm) from the partition were used as heat flux final stops, or optical fiber thermometer temporary repose locations. A data acquisition system using Labtech was used to collect the data.



Figure 1: Cross section in a black body cavity.

### Preliminary Trends

Due to time limitations only a few runs representing the experimental range were studied. Based on these studies we noticed the following trends:

The open Gardon gage consistently gave apparent heat flux measurements approximately twice those measured by the window Gardon gage, as shown in Figure 2. Removing the window, we realized that the internal shape factors caused the decrease in the apparent heat flux, consequently, we stopped using the window Gardon gage.

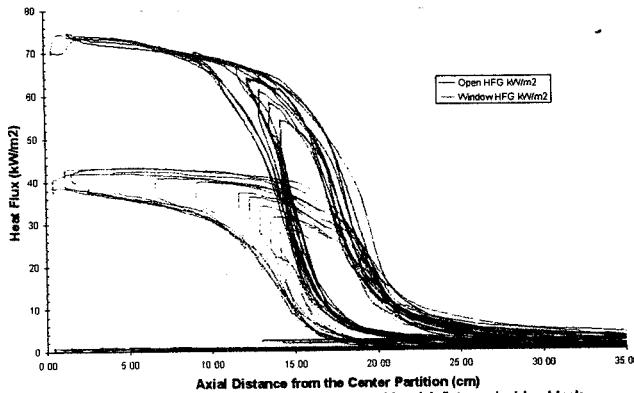


Figure 2: Variation of heat flux measurements with axial distance inside a black body cavity, the center of the partition is at 800 C.

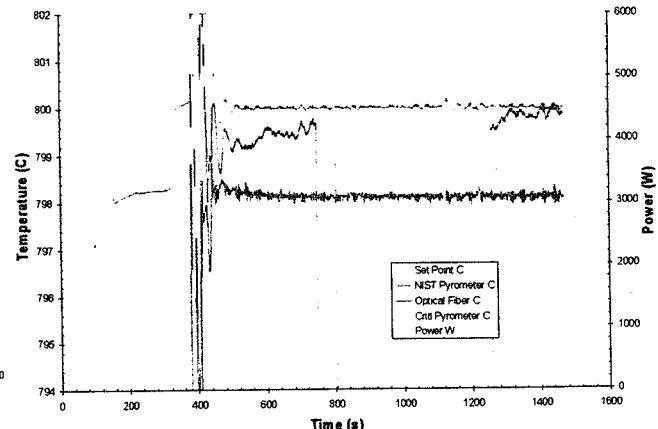


Figure 3: Variation of the control pyrometer temperature with variations in the power input to the black body cavity, the center of the partition is at 800 C

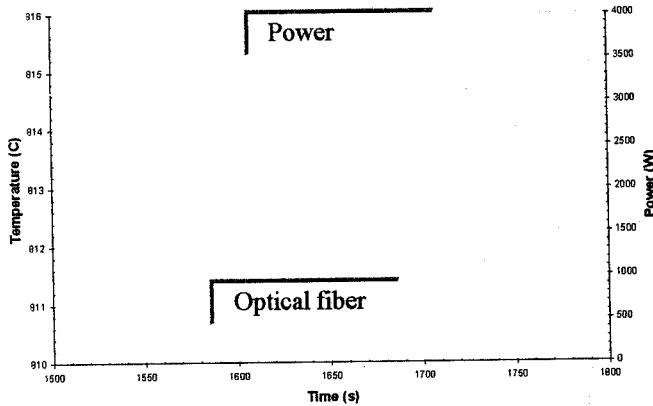


Figure 4: Effect of inserting the optical fiber thermometer on the black body.

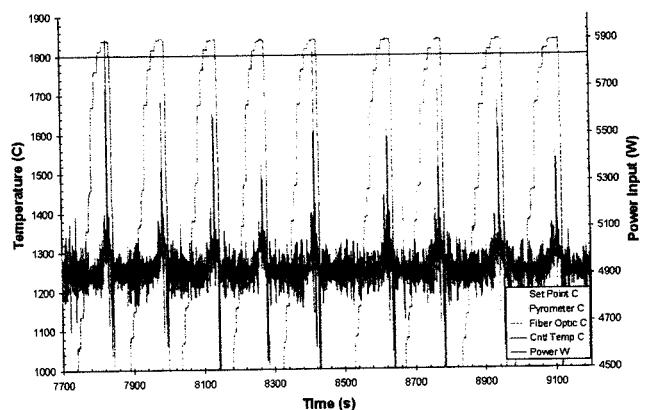


Figure 5: Effect of inserting the optical fiber thermometer in one side of the cavity on the power input. The center of the partition is at 1800 C

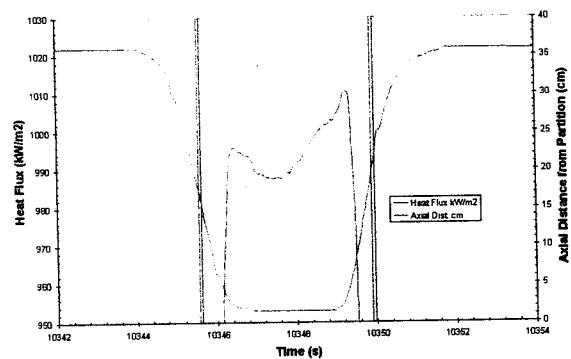


Figure 6: Apparent heat flux measured 1.5 cm from the partition, the center of the partition is at 1800 C

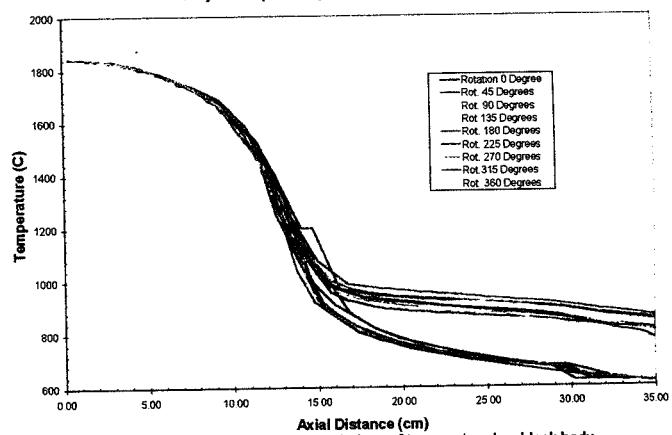


Figure 7: Axial and circumferential variations of temperature in a black body cavity the center of the partition is maintained at 1800 C

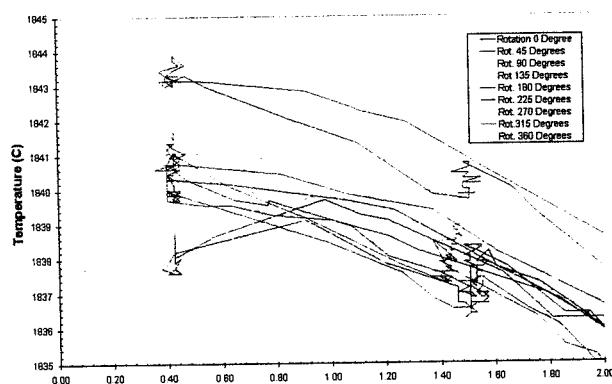


Figure 8: Axial and circumferential variations of temperature in a black body cavity in the vicinity of the partition (center is maintained at 1800 C)

The fluctuations in the power input were in harmony, and consistent with those of the optical pyrometers, and the optical fiber thermometer, as shown in Figures 3 and 4, respectively. Close examination of Figure 4 indicates decrease in the temperature of the black body as the optical fiber thermometer is inserted, then with time the temperature increases to uniformity. The decrease in the black body cavity temperature due to the insertion of the optical fiber thermometer is supported by the increase of power input as the optical fiber thermometer approaches the partition in the middle and thus disturbs the heat in the vicinity of the partition. Consequently, the control pyrometer senses a decrease in the temperature, at the other side of the partition, and signals to the power input to increase as shown by the power spikes in Figure 5. The decrease in the temperature of the black body is also supported by the decrease followed by increase in the measured apparent heat flux, as revealed in Figure 6, where the open heat flux gage is at a final stopping axial position 1.5 cm from the middle partition. This behavior of the heat flux gage, shown in Figure 6, was observed to lesser degrees with increase of axial location from the partition.

The circumferencial peripheral temperatures through the axis of the extension and the black body cavity were recorded and plotted in Figure 7. As the right angle bent optical fiber thermometer enters the black body extension the increase in temperature is shallow, but starting at the mouth of the black body the temperature increases rapidly till approximately the middle of the black body cavity where the increase in temperature becomes shallow. On the way out the temperatures recorded are higher. At this point we did not have enough time to examine comprehensively all the data to determine the role of convection. But, the slot on top of the partition, always decreased the temperature measured by the bent optical fiber thermometer when the thermometer faced the slot, as seen for the 0 and 360 degree rotations, in Figure 8. The peripheral variations in temperatures at any axial location within the 2 cm adjacent to the partition did not exceed 8 °C. At each of the repose axial positions of the optical fiber thermometer the temperature cooled due to the cooling of the black body.

### **Conclusion and Future Directions**

The insertion of a heat flux gage, or an optical fiber thermometer in a black body, for calibration, decreases the temperature (transient condition) of the black body. But many more questions remain to be answered. Can the exact decrease in temperature due to the insertion be predicted? Can we obtain a better prediction of the heat flux? What is the effect of natural and forced convection on the heat flux gage? What is the optimum location of the sensing element of the heat flux gage? Attempting any of these questions is complicated and needs a thorough understanding of the different mechanisms taking place in the black body. Thus, the objective of our future work will be to analyze the data (approximately 30 MB). We will start by using IGOR software to examine the trends in the data. Also, literature searches will be performed for any relevant research, including temperature sensing equipment, Gardon heat flux gages, and reliable physical properties for materials and gases used in the calibration process. Based on the IGOR results, analytical and numerical calculations will be performed to examine the role of the different modes of heat transfer in the calibration of heat flux gages in high temperature black body cavity. The possibility of the graphite oxidizing to carbon oxide will not be ignored.

### **Acknowledgment**

I would like to express my gratitude to Mr. Tom Horn, my NASA colleague, for inviting me to share in this exciting research at Dryden Flight Research Center. Also, I would like to thank the Flight Loads Laboratory Director and Personnel for their help and friendliness.

1998 NASA-ASEE-Stanford Summer Fellowship  
Final Report

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Virtual Reality Simulation of the Effects of  
Microgravity in Gastrointestinal Physiology

Cesar M. Compadre

Associate Professor, University of Arkansas for Medical Sciences

## 1 Introduction

The ultimate goal of this research is to create an anatomically accurate three-dimensional (3D) simulation model of the effects of microgravity in gastrointestinal physiology and to explore the role that such changes may have in the pharmacokinetics of drugs given to the space crews for prevention or therapy. To accomplish this goal the specific aims of this research are:

- 1) To generate a complete 3-D reconstructions of the human gastrointestinal (GI) tract of the male and female Visible Humans.
- 2) To develop and implement time-dependent computer algorithms to simulate the GI motility using the above 3-D reconstruction.

The organs of the GI tract include the oral cavity, oropharynx, esophagus, stomach, small intestine, and large intestine. Once a discrete mass (bolus) of food has been swallowed, it moves through the oropharynx and into the esophagus. The esophagus forms a tube or conduit through which the bolus is passed to the stomach. Movement of the bolus is facilitated by a contractile wave that propagates along the length of the esophagus to the stomach. Once in the stomach the contents undergo physical and chemical digestion and some degree of absorption before being passed to the small intestine. In the small intestine contents are further digested and absorbed prior to passage into the large intestine where water and ions are removed and remain stored until excreted (Ganong, 1997).

It is recognized that microgravity can have pronounced effects on the GI system. Changes in gastric emptying and GI transit can greatly affect the absorption and metabolism of nutrients and can have a critical impact on the bioavailability of orally administered drugs in space (Amidon et al., 1991). In-flight bioavailability data indicate significant changes in absorption of acetaminophen, and scopolamine (Tietze and Putcha, 1994). Recent inflight experiments measuring the appearance of hydrogen in the breath following ingestion of lactulose indicate a significant increase in the GI transit time (Putcha, 1997). With the increase in frequency and duration of manned space flights, and the goal to launch a new manned space station, there is an increasing risk of injury or illness in space. Although on earth most of these problems are treated with well-established therapeutic regimens, in space the uncertainties about drug pharmacokinetics make the use of even the simplest drugs an unpredictable proposition. The lengthy and expensive experimentation involved in gathering the required data for pharmacokinetic studies makes these studies unfeasible in space (Srinivasan et al., 1997). Thus, as indicated by Cintrón and Putcha (1997) "...limited availability of crew time, and operational and technical constraints during spaceflight, dictate that ground based simulations of microgravity be used whenever possible." The computer simulation described in this proposal could be a cost-effective methodology to predict the effects of microgravity on drug kinetics and in other relevant physiological process.

Scientist at NASA and elsewhere have employed compartmental and physiologically based pharmacokinetic (PBPK) models to study the effect of microgravity on the disposition of drugs (Srinivasan et al., 1997). Our proposed model will draw upon the extensive efforts of these scientists, and add the elements of 3D-visualization and physical interactivity.

An essential element in this project is the availability of the Visible Human data set. This set consists of a complete digitized collection of cross-sections of human cadaver. The data was collected by the University of Colorado Health Sciences Center, under contract with the National Library of Medicine. To get the data, the cadavers were embedded in gelatin, frozen and sliced from head to toe using a custom cryomacrotome. As each layer was exposed, a color RGB photograph was taken. 1850, 24-bit images 2048by 1216 were created (Ackerman, 1995). Data for the male was gathered in one-millimeter increments from head to toe (z axis). Each slice was digitized at 1/3 millimeter resolution in x and y. The female was done the same way with three times the resolution in the z direction giving true 1/3 millimeter voxels.

The Visible Human database defines the anatomy of the adult human body in three dimensions at high resolution, as it stands, the paradigm created by the availability of the Visible Human is revolutionizing the way that anatomy is studied and taught. This paradigm is opening new venues for trained health care professionals that are able for the first time to develop, teach, and practice diagnostic and therapeutic procedures in virtual reality patients.

The simulations envisioned, as result of our project will take the Visible Human paradigm to further level. A level, in which simulations based firmly on human anatomy and physiology, will be used to generate new knowledge. For example, as envisioned, the GI simulations will allow the researcher to observe the physiological implications of microgravity and to predict its effects the pharmacokinetics of drugs or in the absorption of nutrients.

## 2. Results

Using the Reconstruction of Serial Section (ROSS) software developed at the NASA Ames Biocomputation Center (Directed by Dr. Muriel Ross, see Montgomery and Ross, 1996) we have successfully generated a 3-D model of the male's Visible Human GI tract comprising 451 sections, from the esophagus to the upper intestine. The reconstruction was accomplished by a process involving the definition of the 3-D object by tracing or contouring the object as it appears in consecutive cross sections and registering the contours of the object in Cartesian space. The registered contours were then imported into a mesh generation program (MrMesh) that defines the polygonal surface of the object. The 3-D anatomically accurate structure was then rendered with various surface characteristics such as shading, colors, or textures.

In contrast to other software that creates volumetric reconstructions, ROSS produced mesh reconstructions consisting of a finite set of vertices and their interconnections. This unique feature of ROSS makes it ideal for this project inasmuch as the mesh lends itself to manipulation by computational techniques.

In the terms of the second specific aim, we have applied a sinusoidal transformation to the GI reconstruction. When this function,  $f(x) = a \sin bx$  (where  $a$  is the amplitude and  $b$  is the periodicity), is applied to the mesh coordinates, it results in a displacement of the vertices in a direction opposite to the vertex normal. Figure 1, depicts a symmetric peristaltic contraction of a

segment of the esophagus. This simulation was performed in our laboratory by using the equation described above.

In addition to the above results we have performed a comprehensive review of the literature regarding the modeling of gastrointestinal motility in normal and in microgravity conditions.

### 3. Future work

The essential element of this project is the synergistic collaboration between the NASA Ames Biocomputation Center and the UAMS Biomedical Visualization Center. The combined sharing of expertise and resources available at these Centers will assure the success of this project. The computer simulation of GI physiology will lend itself as a ground based model system ideal for prediction of the effects of microgravity and it could easily be extended to improve our understanding of related GI physiological, pharmacological and pathological functions in earth's gravity. Work will proceed to complete the reconstruction of the male and female's GI tract. In addition, work will continue to implement the simulation in real-time the peristaltic waves of contractions in the esophagus as they progress into the stomach and upper intestines. The algorithms will be adapted from the description of similar motion in the intestine by Macagno and co-workers (1982). Further development of related functions have been done by Li and co-workers (1994) based on the correlation of manometric and videofluoroscopic data with a 2-D computer simulation of esophageal motility.

### 4. References

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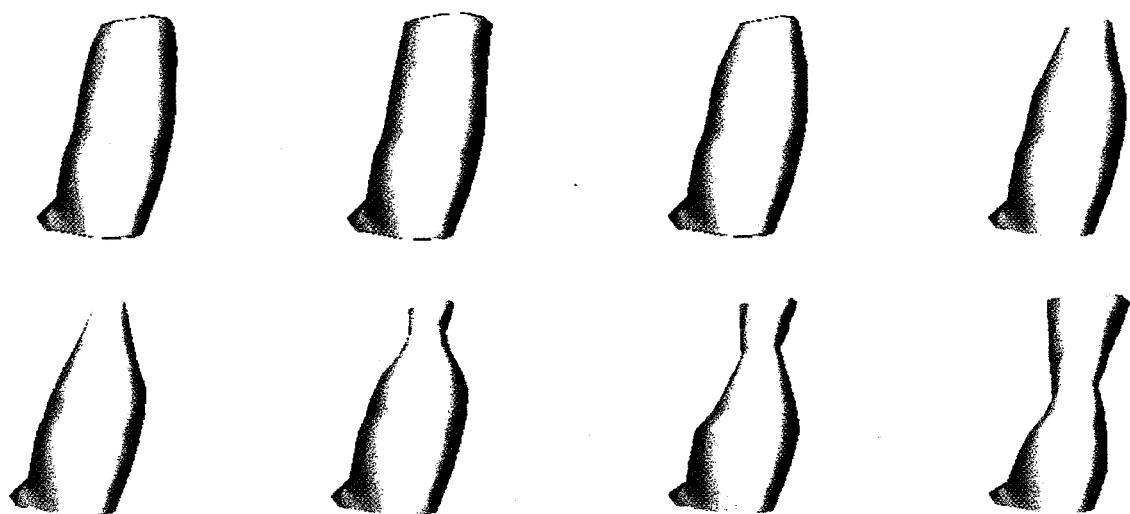


Figure 1: Simulation of a symmetric peristaltic contraction of a segment of the esophagus, progressing from the upper left to the lower right.

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# EDUCATIONAL APPLICATIONS ON THE WORLD WIDE WEB: An Example Using Amphion

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1998 NASA-ASEE-Stanford Summer Fellowship Final Report

Jane Friedman Mathematics and Computer Science Department University of San Diego

There is a great deal of excitement about using the internet and the World Wide Web in education. There are such exciting possibilities and there is a wealth and variety of material up on the web. There are however many problems, problems of access and resources, problems of quality -- for every excellent resource there are many poor ones, and there are insufficiently explored problems of teacher training and motivation. For example, Wiesenmayer and Meadows report on a study of 347 West Virginia science teachers. These teachers were enrolled in a week-long summer workshop to introduce them to the internet and its educational potential. The teachers were asked to review science sites as to overall quality and then about their usefulness in their own classrooms. The teachers were enthusiastic about the web, and gave two-thirds of the sites high ratings, and essentially all the rest average ratings. But alarmingly, over 80% of these sites were viewed as having no direct applicability in the teacher's own classroom.

This summer I was assigned to work on the Amphion project in the Automated Software Engineering Group under the leadership of Michael Lowry. ( See <http://ic-www.arc.nasa.gov/ic/projects/amphion/index.html#papers>.) I wished to find educational applications of the Amphion system, which in its current implementation can be used to create fortran programs and animations using the SPICE libraries created by the NAIF group at JPL. I wished to find an application which provided real added educational value, which was in line with educational curriculum standards and which would serve a documented need of the educational community. The application selected was teaching about the causes of the seasons -- at the approximately the fourth, fifth, sixth grade level.

This topic was chosen because it is in line with national curriculum standards. The fourth, fifth, sixth grade level was selected to coincide with the grade level served by the Ames Aerospace Encounter, which services 10,000 children a year on field trips. The hope is that eventually the Ames Aerospace Encounter could be used as a test bed for the lessons developed. The topic is one which is difficult to teach and the necessity for new methods is documented in the educational literature.

Current educational standards indicate that seasons should be part of the elementary school curriculum. The National Science Education Standards, ( see <http://www.nap.edu/readingroom/books/nses/html/>) written by the National Research Council include the seasons as part of the K-4 and the 5-8 curriculum standards.

## K-4 Content Standards:

*Objects in the sky have patterns of movement. The sun, for example, appears to move across the sky in the same way every day, but its path changes slowly over the seasons. The moon moves across the sky on a daily basis much like the sun. The observable shape of the moon changes from day to day in a cycle*

*that lasts about a month.*

## **5-8 Content Standards:**

*The sun is the major source of energy for phenomena on the earth's surface, such as growth of plants, winds, ocean currents, and the water cycle. Seasons result from variations in the amount of the sun's energy hitting the surface, due to the tilt of the earth's rotation on its axis and the length of the day.*

The seasons are a difficult topic to teach, and these same standards recognize that fact

*By grades 5-8, students have a clear notion about gravity, the shape of the earth, and the relative positions of the earth, sun, and moon. Nevertheless, more than half of the students will not be able to use these models to explain the phases of the moon, and correct explanations for the seasons will be even more difficult to achieve.*

This pessimism about childrens' understanding of the seasons is justified. Research into children's misconceptions indicate that children rarely have a scientific understanding of day or night, the phases of the moon, or the seasons. Of these alternative concepts, that of the seasons is the most difficult to change. ( See Driver et. al (1985), and Sharp (1996).) One reason for this is that many different concepts are involved. First of all the children need to have a good understanding of the earth concept and the earth's place in solar system. They must understand that the earth is an approximate sphere, and that it rotates around the sun. To understand the causes of day and night they must understand that the earth rotates on its axis. To understand the seasons, they must keep all the afore-mentioned concepts straight and know that the earth is tilted on its axis, and in addition understand the effect of the axial tilt on the amount of sunlight reaching the earths surface. This is a complicated network of concepts.

Elementary school teachers and future elementary school teachers share many of the same misconceptions as the children they are to teach. (See Atwood and Atwood (1996, 1997), Harlan and Holroyd (1997), Lawrenz (1986) and Parker and Heywood (1998).) These teachers also find it difficult to learn and retain the correct scientific understanding of these astronomical processes. And the causes of the seasons is the most difficult concept to learn for the teachers as well as for the students. Some success can be achieved by using models composed of balls and a light source.

For both children and teachers one of the most common alternate conceptions of the causes of the seasons, is that it involves the distance between the earth and the sun. The reasoning is plausible, the earth is warmed by the sun, so one might imagine that if the earth is farther from the sun then we might experience winter and experience summer when it is closer. Current pedagogical theory emphasizes the importance of "hands-on" science. In studying the solar system "hands-on" science of necessity involves models, and is thus inevitably somewhat abstract. Much success can be achieved through the use of models composed of balls to represent the bodies and a light source. However, even this approach is not always effective in teaching about the causes of the seasons, partly due to misconceptions caused by the abstract nature of the models.

Atwood and Atwood (1997) conducted an interesting study of preservice elementary school teachers. In this study they administered pre and post tests of the subjects understanding of the causes of day and night and the seasons. Prior to the post-test they provided the subjects with training with models. On the pre-test 36 out of 51 subjects could provide the scientific explanation for the causes of day and night, while all 51 subjects could do so on the post-test. In contrast, only one subject could provide a scientific

explanation of the causes of the seasons on the pretest and 42 could do so on the post-test. So even after training on models 9 out of 51 subjects were still confused about the causes of the seasons. One explanation for this problem is that the models themselves give rise to misconceptions. Due to the scale of the model it appears that the axial tilt causes a significant difference in distance between the southern and northern hemispheres and the sun. This may re-enforce the common misconception that the cause of the seasons is related to the distance between the earth and the sun. Atwood and Atwood suggest that *an additional or alternative instructional mode is needed, such as a well-designed interactive computer simulation which shows light intensity values for areas in the northern and southern hemispheres as the earth revolves around the sun*. We are working to create such a simulation using the Amphion system.

## General Conclusions

The web may have great educational potential, but it takes care to produce web-based materials which will actually be used. It is important to address concepts in educational standards. The materials should have some added value over text-books or other methods of delivering content. Educational research into learning and pedagogy can be used to target real needs.

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415334

1998 NASA-ASEE-Stanford Summer Fellowship  
Final Report

31.

Detection of Polar Stratospheric Clouds using AVHRR Imagery

Oswaldo Garcia  
Professor of Meteorology  
San Francisco State University

360070

## 1 Introduction

In recent years, the role of PSCs in the ozone depletion process has become better understood. PSCs provide the surfaces upon which heterogeneous reactions take place that affect the gas phase partitioning between active and reservoir chlorine and nitrogen species [Solomon et al., 1986; Toon et al., 1986; Turco et al., 1989; Hamill and Toon, 1991].

Present methods of PSC detection include in situ measurements by lidar and various satellite-borne instruments such as the Stratospheric Aerosol Measurement II (SAM II) on the Nimbus 7 spacecraft, which produced PSC measurements from 1978 to 1994 and several instruments onboard the Upper Atmospheric Research Satellite (UARS) such as the Cryogenic Limb Array Etalon Spectrometer (CLAES) which provided measurements for 1991-1993. All of the PSC-detection methods devised so far have been hampered by incomplete sampling of the places and times in which PSCs are likely to form.

There is a need to understand the climatology of PSCs, in particular the timing of their onset and duration, their vertical distribution, geographic extent, annual variability and responses to volcanic aerosol forcing. Poole and Pitts [1994] assembled a PSC climatology based on SAM II data, but this climatology is incomplete, as it is limited to the edge of the polar night due to the limitations of the solar occultation scan geometry.

The Advanced Very High Resolution Radiometer (AVHRR) five-channel sensors onboard the NOAA polar-orbiting satellites have been collecting data over the polar regions continuously since 1979 [Burroughs, 1991]. These operational satellites provide unmatched coverage in space and time of both polar regions, but were not designed for the detection of optically-thin PSCs. However, the AVHRR data archive would be an invaluable source for the construction of a long-term climatology of PSCs if techniques can be developed and tested to detect PSCs in AVHRR data. In the last few years, the members of our group at San Francisco State University and NASA Ames Research Center have been engaged in the development of various PSC detection methods using AVHRR data. There is strong evidence that a subset of PSCs, those that are optically thick, can be readily identified in

the AVHRR data set. Our group has also made significant progress in the identification of optically thinner PSCs using a variety of techniques. (see <http://nube.sfsu.edu>)

## 2. Summer 1998 Accomplishments

During this summer we continued work on validating the presence of PSCs on AVHRR imagery using data from the CLAES instrument . As CLAES data is obtained from a limb-viewing satellite, it is difficult to compare directly with data from the nadir-viewing AVHRR instrument aboard the NOAA polar-orbiting satellites. In collaboration with Kathy Pagan at AMES, we completed and tested a program that will allow for an accurate intercomparison for the stratospheric volumes jointly sampled by both instrument. We plan to continue this intercomparison work during the fall with a view toward presenting our results at the 1999 spring meeting of the American Geophysical Union in Boston

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415335

# Testing and Troubleshooting Automatically Generated Source Code

ASEE Summer Faculty Fellowship Research Report Abstract

360013

**Joel Henry, East Tennessee State University**

31.

## MOTIVATION

Tools allowing engineers to model the real-time behavior of systems that control many types of NASA systems have become widespread. These tools automatically generate source code that is compiled, linked, then downloaded into computers controlling everything from wind tunnels to space flight systems. These tools save hundreds of hours of software development time and allow engineers with thorough application area knowledge but little software development experience to generate software to control the systems they use daily.

These systems are verified and validated by simulating the real-time models, and by other techniques that focus on the model or the hardware. The automatically generated source code is typically not subjected to rigorous testing using conventional software testing techniques. Given the criticality and safety issues surrounding these systems, the application of conventional and new software testing and troubleshooting techniques to the automatically generated will improve the reliability of the resulting systems.

## PROBLEM STATEMENT

Testing and troubleshooting tools are needed to evaluate and improve the reliability and safety of automatically generated source code. Such tools will combine to form a tool set which is effective, timely, and integrates easily into the existing control system development and maintenance. In order to develop tools, four significant questions must be addressed:

1. How do properties of automatically generated code affect reliability and safety?
2. Can existing and new techniques be effectively automated and applied to automatically generated code?
3. What testing methodologies should be applied to automatically generated code?
4. How effective are the tools when integrated into the existing system development process?

Answers to these questions will produce testing and troubleshooting tools targeting automatically generated code. The resulting tools will have been subjected to evaluation in a "real world" situation. Such an evaluation will suggest further improvements and enhancements to the tools, which will make them applicable and desirable in additional application areas across NASA.

## SOLUTION APPROACH

This ongoing study focused on a set of cooperative techniques that together provide a powerful toolset for testing and troubleshooting real-time software. This section addresses the progress on each task within the proposed solution approach, and provides information about additional approaches attempted while conducting this research.

### *Investigate Properties of Automatically Generated Code*

Automatically generated source code has been closely studied using code metrics tools (PC Metric and Cdoc). Additional software tools (diff, grep, etc.) and small programs have been used to further examine specific issues. The initial analysis of code generated from Matrix X models from the unitary wind tunnel show the following characteristics:

- most source code is placed in a single large file, many of which exceed 30,000 lines of code
- path complexity of many functions exceeds 15 (a common industry standard), although this complexity results from simple *if* statements or *switch* statements with large numbers of cases
- there are numerous floating point comparisons with potential nondeterministic behavior
- a large number of *structs* are created and used to pass data
- pointers are passed as arguments to functions; these pointers are never checked for NULL values

This step in the investigation has determined that testing should focus on path coverage, boundary values, and stress testing. Troubleshooting techniques should focus on automatic instrumentation of source code. The current goal of instrumentation is to automate the placement of assert statements in source code to assist troubleshooting software.

### *Evaluate Applicability of Existing Methods*

Existing techniques for verifying and validating software have been, and continue to be, examined for applicability to automatically generated code. The following testing methods are being examined for use in this research:

- Black box
- Boundary value
- Cyclic random number
- Critical value

Black box has proven to be difficult because of the large number of inputs and outputs generated. Thousands of inputs are consumed and outputs generated every second a real-time control system is in operation. Current efforts in the area of black box testing are to create an automated tool to support simulation of real-time code within the Matrix X environment, and efforts to execute the autogenerated code using input from the simulation and capturing output for comparison with simulation output.

Boundary value testing based on boundary values specified in requirements specification is also currently under development. Efforts in this area include the ability to test using values outside boundaries, exact boundary, and within but very close (using ISO Standard definitions for FLT\_EPSILON and DBL\_EPSILON) to boundary values. The goal of this effort is to automate this type of testing and apply test cases to both simulation and autogenerated software.

Cyclic random number testing is defined as the testing of values cycling between limits in random increments of change in first one direction, and then the opposite direction. Advice from controls engineers indicates that smooth cycles (such as a sine wave) rarely occur in practice and that non-uniform increases and decreases are more likely. This effort is to automate this type of testing and apply test cases to both simulation and autogenerated software.

Critical value testing is an effort to provide automation for testing between critical values. This technique can be applied between boundary values or between any two values supplied by the controls engineer. This technique can also be used for troubleshooting. For example, should an error occur between two input points within a long sequence of inputs, those two input points can be used as critical values for testing.

### ***Propose Testing Strategy for Automatically Generated Code***

A testing strategy is being formulated. This strategy includes automated testing through simulation, testing autogenerated code with input identical to that used for simulation, and automated troubleshooting using *assert* statements. Further, the test input and output should be saved to support regression testing at a later date. Testing should include automated testing of large numbers of tests relying on the automated testing too. Review of test results should be both graphical and suitable for detailed examination of exact numerical output. A complete methodology will be formulated and assessed during Year 2 of this effort.

### ***Assess Proposed Testing Methodology***

This is a follow on effort.

## **CURRENT RESULTS**

In addition to solution methods and proposed approaches, current results include:

- Detailed examination of autogenerated code characteristics
- Detailed comparison of autogenerated code from Matrix X Autocoder versions 5.02, 5.10, and 6.03
- Creation of automated testing tools for use with the Matrix X simulator
- Creation of a tool for automated placement of assertions within C program source code
- Examination of using Matrix X template files for inserting path coverage measurement

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1998 NASA-ASEE-Stanford Summer Fellowship  
Final Report

F18 Life Support  
APECs and EDOX Cockpit Integration

Paul Herrick  
Associate Professor, University of Alaska Anchorage

360014

38

### Introduction:

Two systems are currently being integrated into the F18 Hornet support aircraft at NASA Dryden Flight Research Center (DFRC). The first system is the Aircrew Personal Environmental Control System (APECs). The system is designed to increase aircrew performance by combating heat stress in the cockpit. The second system is the Extended Duration Oxygen System (EDOX). This system will provide additional redundancy and oxygen system duration to the F18 without extensive modification to the current system.

### APECs:

The APECs system consists of a shirt worn by the aircrew member which has a series of small diameter tubes sewn to the interior. These tubes are supplied with a liquid mixture of 70% water and 30% isopropyl alcohol which acts as a heat sink to draw heat away from the crewmember during periods of high heat load. Heat load for crewmembers can result from the insulating nature of the crew garments and equipment worn, hot environments and mission stress. The heat extracted at the garment is removed from the liquid by passing it through tubing to a heat exchanger which uses cooling air from the aircraft environmental control system (ECS) (see Figure 1).

A location in the F18 ECS ducting found in the upper equipment bay was identified as the most suitable location for the heat exchanger. The pump is to be located adjacent to the heat exchanger with power being provided from the lighting control panel in the equipment bay. The liquid tubing will be routed to the crew services panel on the left console where a quick disconnect fitting will attach the APECs garment to the aircraft system (see Figure 2).

Once the system is installed, the Brooks AFB human performance lab will begin instrumenting crewmembers to obtain quantitative data regarding changes in body temperatures and crew performance to evaluate the system for military installations. In qualitative evaluations of a prototype system the crew comments were all favorable and qualitative test should reveal further benefits.

### EDOX:

The EDOX regulator system was incorporated in the F18 to provide greater duration from the oxygen system, particularly the emergency backup. The existing F18 system has a harness mounted diluter-demand regulator (uses cabin air mixed with oxygen system to prolong oxygen duration) which is difficult for the crewmember to see and manipulate. Additionally, the emergency system is continuous flow (supplies continuous oxygen flow which can leak from the mask, wasting oxygen).

The system developed was designed to use a diluter-demand panel mounted regulator which is easier for the crewmember to operate while having good oxygen conservation. With the addition of an extra line the system can operate in the emergency condition from the old F18 system while still having the demand function (supplies 100% oxygen only when the crewmember breathes) which conserves oxygen. In addition, the emergency bailout system located in the ejection seat also functions in the demand mode providing increased duration during operation of that system (see Figure 3).

During operation of the bailout system a 50% increase in duration is anticipated and testing is planned to verify this increase. Additional benefit is obtained over the existing system by adding one additional

emergency mode thereby creating a triple redundancy without extensive changes to the present aircraft system.

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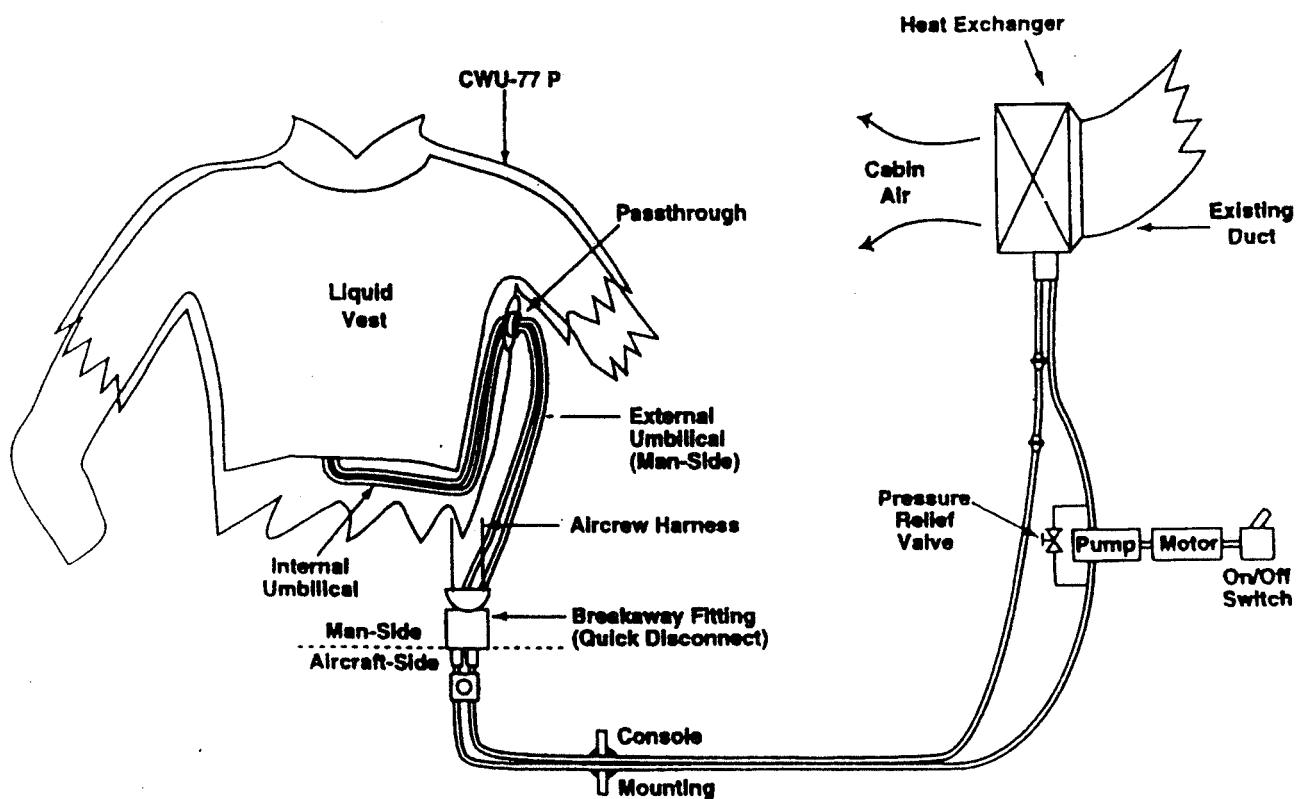


Figure 1.

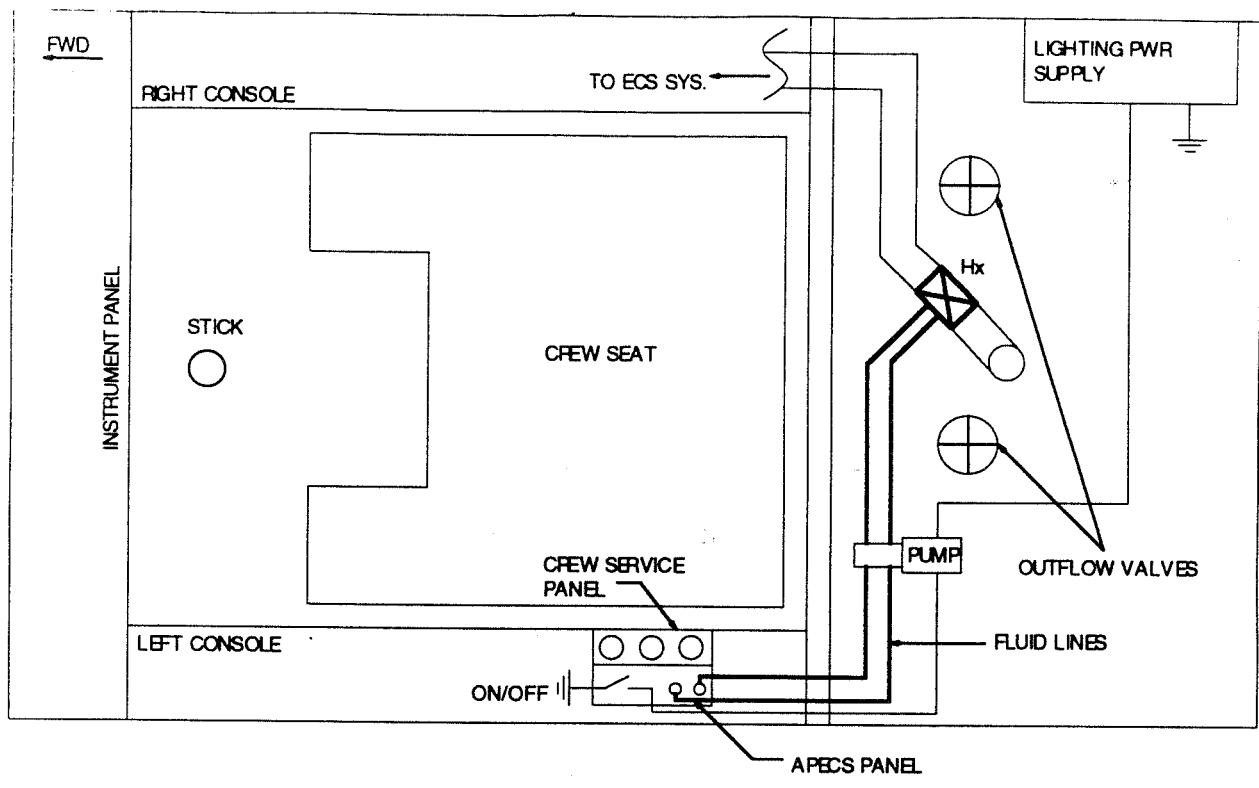


Figure 2.

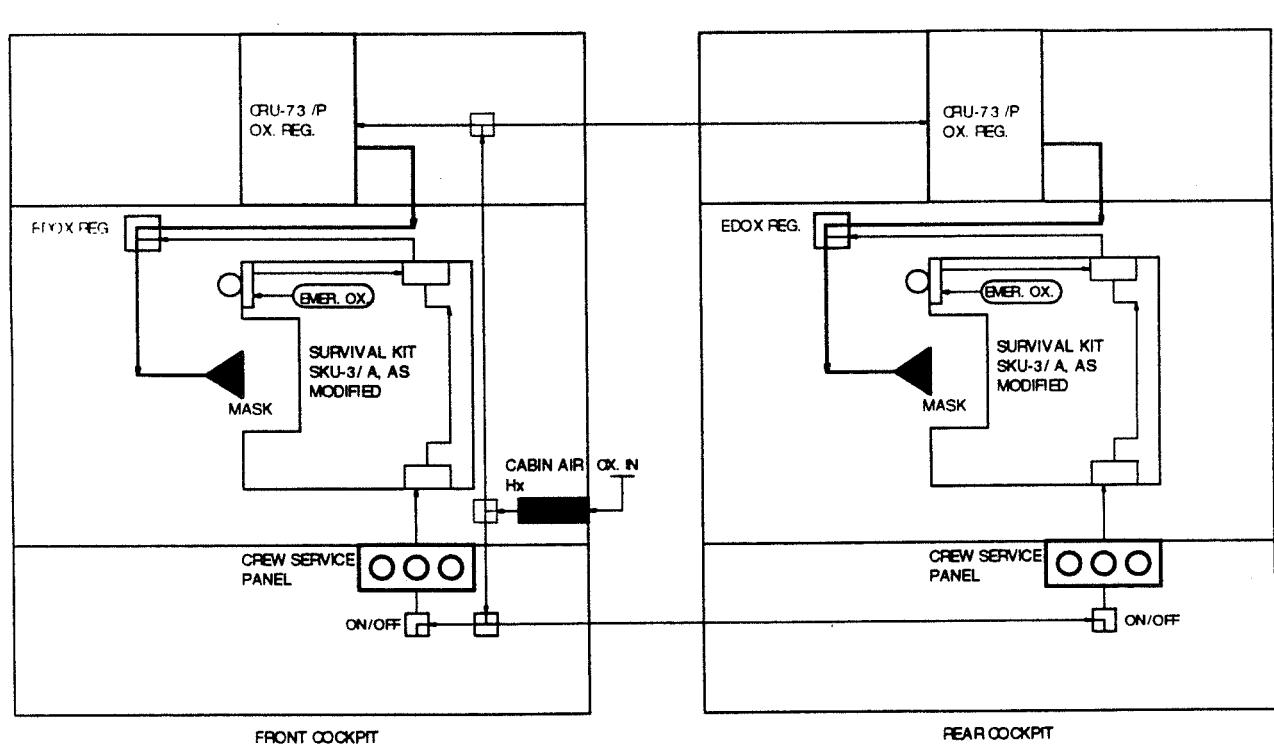


Figure 3.

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1998 NASA-ASEE Stanford Summer Fellowship - Final Report

416337

High resolution airborne digital imagery for precision agriculture

31

Stanley R. Herwitz, Ph.D., Professor of Biogeography & Earth Science, Clark University, Worcester, MA 360076

**Introduction.** The Environmental Research Aircraft and Sensor Technology (ERAST) program is a NASA initiative that seeks to demonstrate the application of cost-effective aircraft and sensor technology to private commercial ventures. In 1997-98, a series of flight-demonstrations and image acquisition efforts were conducted over the Hawaiian Islands using a remotely-piloted solar-powered platform (Pathfinder) and a fixed-wing piloted aircraft (Navajo) equipped with a Kodak DCS450 CIR (color infrared) digital camera. As an ERAST Science Team Member, I defined a set of flight lines over the largest coffee plantation in Hawaii: the Kauai Coffee Company's 4,000 acre Koloa Estate. Past studies have demonstrated the applications of airborne digital imaging to agricultural management [1, 2]. Few studies have examined the usefulness of high resolution airborne multispectral imagery with 10 cm pixel sizes [3, 4]. The Kodak digital camera integrated with ERAST's Airborne Real Time Imaging System (ARTIS) which generated multiband CCD images consisting of  $6 \times 10^6$  pixel elements. At the designated flight altitude of 1,000 feet over the coffee plantation, pixel size was 10 cm. The study involved the analysis of imagery acquired on 5 March 1998 for the detection of anomalous reflectance values and for the definition of spectral signatures as indicators of tree vigor and treatment effectiveness (e.g., drip irrigation; fertilizer application).

**Materials and Methods.** ARTIS images acquired with a blue-blocking filter were interpolated into multiband (NIR, red, and green) 18 MB tif files using Kodak's G10 non-uniformity correction algorithms. These files were downloaded to a Sun workstation and imported into the GIS software Erdas Imagine (ver. 8.3). Determination of the spatial variation in multiband reflectance at scales ranging from individual trees to field-blocks involved: (1) adjustments in contrast and brightness, and the restacking of false color waveband combinations for image enhancement; (2) screen-based digitization of polygons representing the unshaded sections of selected trees, rows, and field-blocks; (3) cross-sectional image profiling; and (4) statistical analysis of the waveband brightness values in the digitized polygons. The USGS 1:24,000 topographic sheets representing southern Kauai were scanned using an Astra 1200S scanner and imported into Imagine for georeferencing of the acquired images. Comparisons were made with the GPS recording outputs at the time of the overflights. The imagery was overlain by a digitized map of the Kauai Coffee Company's field-block system in order to define the precise locations of specific trees and rows. On-site ground-truthing on Kauai was conducted over the period 16-20 June 1998.

**Results.** The following spectral reflectance anomalies were detected in the digital imagery and assessed by on-site ground-truthing: (1) a reduction in reflectance, which was most pronounced in the NIR waveband (Fig. 1), was correlated with a black sooty fungal mold (*Cladosporium cladosporioides*) on foliar surfaces as a result of honeydew secretions from green scale insects (*Coccus viridis*); (2) patches of a distinctive brightness tinge radiating outward from canopy gaps were correlated with the proliferation of climbing vines (*Ipomoea triloba*); and (3) enhanced brightness in the red and green, but not the NIR, wavebands in rows 63-65 in field no. 418-8 (Fig. 2) was attributed to water-stress induced asynchronous flowering caused by a malfunction in the

drip irrigation system. These results clearly demonstrated the usefulness of airborne real time digital imaging for locating sites requiring management treatments.

Mean brightness of the 80 neighboring coffee row trees shown in Fig. 2 also revealed some unexpected general trends outward from nadir view that differed for the 3 wavebands. NIR had the more prominent nadir brightness, decreasing much more steeply than the other 2 wavebands outward to the edges of the scene. All 3 wavebands exhibited significant brightness differences at the left and right edges of the scene that could not be attributed to variations in tree vigor. Since each pixel in the CCD array can only directly measure the brightness in 1 of the 3 wavebands, I conducted a series of laboratory-based controlled-light experiments to examine the possibility that the Kodak algorithms for interpolating the other 2 colors at each pixel may have introduced artifacts responsible for the unexpected cross-image trends.

The response curves of the Kodak camera's color filter array to narrow wavelengths (3 nm) involved photographing the collimated beam generated by an Acton SpectraPro 275 monochromator (Acton Research Corp.) at 10 nm increments between 400 and 1000 nm. Sixty photographic runs revealed that there is more variation in CCD pixel sensitivity across different wavelengths (Fig. 3) than indicated in Kodak's purported normally distributed response curves. The variation in pixel light-sensitivity was further examined by photographing a uniform light field in an integrated sphere. A minor decrease in brightness outwards from nadir view to the edges of the image as a result of vignetting was evident in each of the raw image layers before interpolation. However, after interpolation, the waveband layers differed markedly. The vignetting trend was greatly exaggerated in the NIR, eliminated in the red waveband, and a brightness artifact characterized the left side of the image in the green waveband. These non-uniformities under uniform light-field conditions were attributable to Kodak's interpolation algorithms. Corrections determined from the uniform light-field test are now being applied to the acquired ARTIS imagery.

**Future Activities.** The databases obtained from the image analyses and from the controlled light-field experiments will be reported in manuscripts to be submitted to the journals *Photogrammetric Engineering and Remote Sensing*, and *Crop Science*. The potential of repeat airborne coverage for monitoring the spatial and temporal patterns of coffee cherry ripening, and for identifying precise locations of peak ripeness for harvest optimization remains to be explored. To address these issues, I am preparing a proposal to be submitted to NRA-98-OES-09 (Remote Sensing Applications to Agriculture). The objective will be to further refine the procedures for image enhancement and to define the spectral signatures of ripening coffee cherries.

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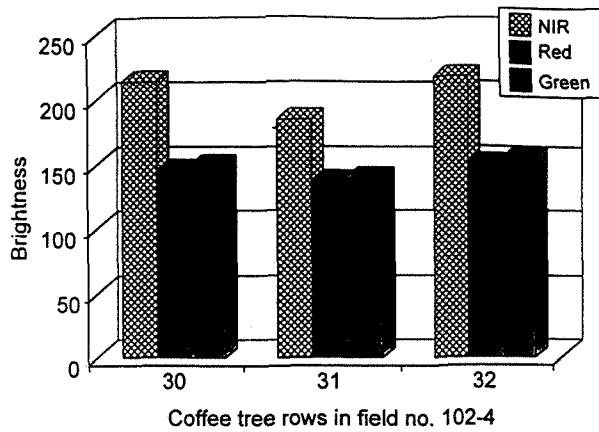


Fig. 1. Waveband brightness differences between vigorous rows of coffee trees (rows 30 and 32) and a black sooty foliar mold infested neighboring row (row 31).

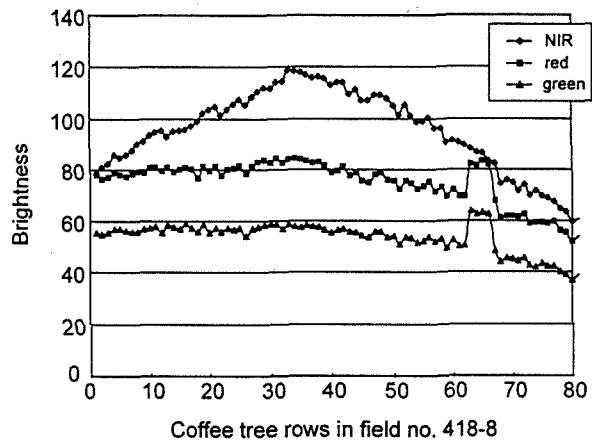


Fig. 2. Waveband brightness values in a succession of rows representing the entire cross swathe section of a full digital image scene. Each brightness value is a mean derived from the digitized polygon representing the midsection of each row.

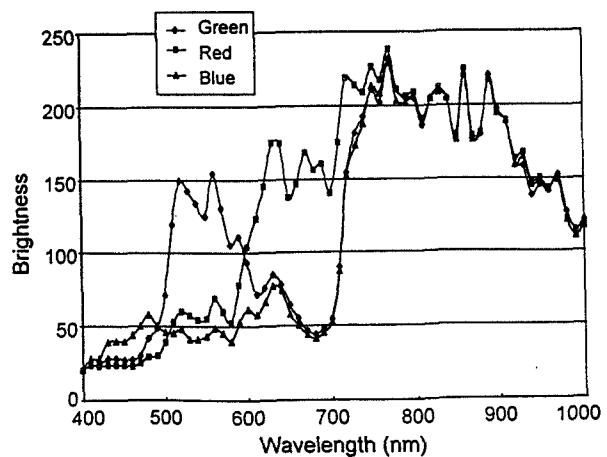


Fig. 3. Brightness values determined for the green, red, and blue sensitive pixel arrays constituting the Kodak digital camera's CCD based on experimental runs using a collimated beam at 10 nm increments between 400 and 1000 nm.

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**Photometric Study of Uranian Satellites**  
**1998 NASA / ASEE Summer Faculty Fellowship Report**

Philip R. Kesten, Santa Clara University  
August, 1998

360077

### Abstract

The best summary of my work at NASA is expressed in the following abstract, submitted to the Division for Planetary Science of the American Astronomical Society and to be presented at the annual meeting in Madison in October:

*Submitted by: P. R. Kesten (Santa Clara University), J. K. Davies (JAC Hawaii), D. P. Cruikshank (NASA Ames), and T. L. Roush (NASA Ames)*

We report photometric measurements of Uranian satellites Miranda, Ariel, Umbriel, and Titania (10.4 Aug. 1995), and Neptune's satellite Triton (21.2 Sept. 1995) with the infrared camera (IRCAM) and standard J (1.13 – 1.42  $\mu\text{m}$ ), H (1.53 – 1.81  $\mu\text{m}$ ), and K (2.00 – 2.41  $\mu\text{m}$ ) filters at the 3.8-m UKIRT telescope on Mauna Kea. The individual images frames are 256 x 256 pixels with a platescale of .286 arcsec/pixel, resulting in a 1.22 arcmin field of view. The standard star used for airmass correction and flux calibration was UKIRT FS 34 (EG141). The photometric information was derived from 5-image mosaics created after dark frame and flat field corrections; a circular aperture approximation based on DAOPHOT/aper-irtf (P. B. Stetson, PASP 99, 191, 1987) was used except in the case of Miranda, in which a linear fit to the strong background light gradient from the nearby image of Uranus was applied. The center of Uranus was 9.7 arcsec (measured on the images) from Miranda. Triton data were extracted from the individual images (not mosaics) with an 8-arcsec aperture and a sky annulus 10–15 arcsec. The phase angle of the Uranian satellites was  $\alpha = 1.0^\circ$ , and that of Triton was  $\alpha = 1.73^\circ$ . The resulting magnitudes are as follows: Miranda J = 15.30 ± .05, H = 15.14 ± .05, K = 15.40 ± .06; Ariel J = 12.96 ± .04, H = 12.86 ± .04, K = 13.04 ± .04; Umbriel J = 13.60 ± .04, H = 13.37 ± .04, K = 13.44 ± .04; Titania J = 12.58 ± .04, H = 12.44 ± .04, K = 12.60 ± .04; Triton J = 12.26 ± .04, H = 12.14 ± .04, K = 12.31 ± .04. Other reports of Uranian satellite photometry are: P. D. Nicholson and T. J. Jones (Icarus 42, 54, 1980), D. P. Cruikshank (Icarus 41, 246, 1980), and K. H. Baines, et al. (Icarus 132, 266, 1998).

### Descriptive summary

This summer brought the IR photometry measurements – work I started last summer – nearly to a close. As indicated by the abstract above, I will present this work at the annual DPS meeting in October. In anticipation of the opening of the new Carl Sagan Laboratory for Cosmochemistry, of which I will be a participating member, I also devoted a considerable fraction of the summer to learning (for the first time, unfortunately!) the biochemistry which underlies the experiments to be conducted. To put the end of the summary close to the beginning, it was a most productive summer.

### IR Photometry

Photometry and molecular spectroscopy are powerful tools with which to determine the constituents and characteristics of solid and particulate objects. Some wavelengths of light passing through or reflecting from a material are absorbed according the excitation energies of the molecules; spectroscopic analysis of the wavelength regions which are absorbed, and the level of absorption, allows a determination of the molecular makeup of the material. To determine the amount of any particular constituent, however, requires knowledge of the absolute fluxes at the various wavelengths of interest; photometry, the measurement of absolute light levels, that is, of absolute energy fluxes, is the usual way in which the absolute levels are set for astronomical objects.

Photometry can be carried out in any wavelength regime. The infrared (IR), in particular the near IR (approximately 1 to 2.5  $\mu\text{m}$ ), is a particularly important wavelength band for spectral analysis. First, the ices of both simple and complex molecules, like  $\text{CH}_4$  and  $\text{NH}_3$ , have vibrational modes with energies corresponding to near IR wavelengths – in other words, these ices absorb energy in the near IR, producing signatures in the IR spectrum which can uniquely identify these ices. In addition, the Earth's atmosphere is relatively transparent to near IR light, which allows for ground-based observations.

Astronomers use a set of relatively standard set of filter bands for photometry; those in the near IR are named J, H, and K. The specific wavelengths of these filters vary from facility to facility, but the central wavelengths are about 1.25  $\mu\text{m}$ , 1.65  $\mu\text{m}$ , and 2.21  $\mu\text{m}$  respectively for J, H, and K. Thus a typical data set to be used in an IR photometry analysis will include at least one set of images recorded through each of these three filters.

## Data

My photometric study of the inner Uranian satellites are based on a set of JHK images recorded on August 10, 1995, starting at 10:00 UT, using the United Kingdom Infrared Telescope (UKIRT) on Mauna Kea. The UKIRT optics are of a classical Cassegrain design; the primary mirror is 3.8 m in diameter. Images were recorded with the IRACAM camera, an InSb array of 256 by 256 square pixel sensitive in the 1  $\mu\text{m}$  to 5  $\mu\text{m}$  wavelength region. With the telescope's optical arrangement, the pixel size corresponds to .286 arc seconds of sky, resulting in a field of view of just over 73 arcsec.

Two sets of JHK images of Uranus and one set of an appropriate standard star were recorded and post-processed in a standard way. The standard star, in this case UKIRT FS-34 ("Faint Star 34"), was selected on the basis of its proximity to Uranus in the sky, and also because its spectral characteristics are both well known and similar to those of the sun.

Uranus is well-centered in the images, therefore any other objects within approximately one half of 73 arcsec from Uranus are also visible. At the time of these observations, Miranda, Ariel, Umbriel, and Titania were all well within the field of view; Oberon, the fifth of the bright Uranian satellites, was approximately 40 arcsec from Uranus (on the sky) and therefore not within the field of view. My analysis therefore includes only Miranda, Ariel, Umbriel, and Titania.

## Analysis

In this analysis there are five objects: four satellites and one photometric standard star. For each object and each image, the total number of pixel counts above background was determined by adding all pixels with a radius of 10 pixels from the apparent center of the object. For all but Miranda, the background was determined by adding all pixels in annulus between a radius of 12 and 16 pixels, that is, an annulus 4 pixels wide an offset 1 pixel from the circular aperture. For Miranda, the background level was determined by fitting a straight line to the pixels near but not including Miranda.

The size of the aperture and the width and offset of the annulus were determined by requiring that the number of counts within the region was relatively unchanged by increasing or decreasing the size, width, or offset, and that perimeter of the region remained relatively well separated from other objects in the image. The signals measured were found to be insensitive, within the errors, to small changes to the aperture radius, annulus width, and annulus offset as defined above.

Because the magnitudes in JHK of the standard star are well known, the magnitudes of the Uranian satellites can be determined from

$$M_{obj} = M_{FS} - 2.5 \log\left(\frac{I_{obj}}{I_{FS}}\right) ,$$

where  $M_{obj}$  and  $M_{FS}$  are the magnitudes of the object and faint star standard respectively, and  $I_{obj}$  and  $I_{FS}$  are their measured pixel counts above background. In order to apply the results to full spectra of the Uranian satellites, geometric albedos are determined from the magnitudes; magnitude is a measure only of the amount of light observed, while geometric albedo accounts for the brightness of the sun in a given wavelength band as well the geometrical factors such as the physical size of an object and its distance from Earth. The geometric albedo  $p_\lambda$  is defined by

$$2.5 \log(p_\lambda) = M_{obj} - M_S + 5 \log(r) - 5 \log(R \cdot \Delta) ,$$

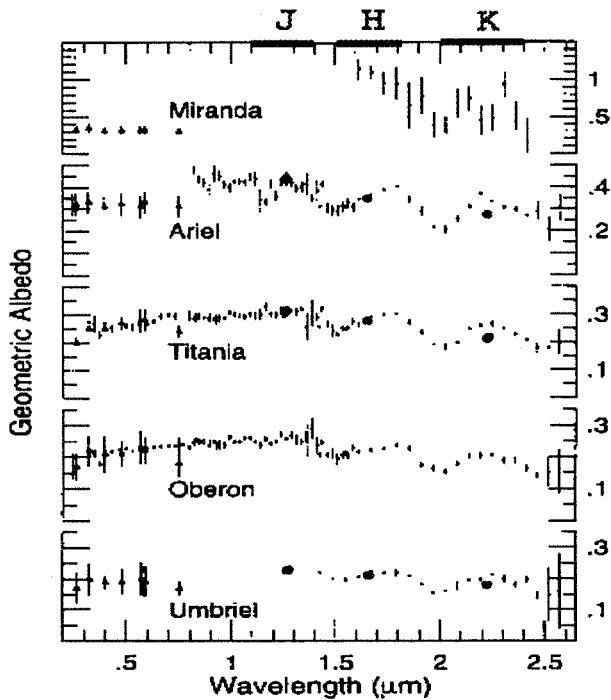
where  $M_S$  is the magnitude of the Sun,  $r$  is the mean radius of the object,  $R$  is the heliocentric (Sun to object) distance, and  $\Delta$  is the topocentric (Earth to object) distance. All distances must be measured in Astronomical Units (AU). Both the determination of  $M_{obj}$  and  $p_\lambda$  are wavelength dependant, that is, these measurements must be made separately in J, H, and K.

## Results

Results of this work are summarized in the following table:

Filter	Object	M	Error	$p_\lambda$	Error
J	Titania	12.58	0.01	0.32	0.00
	Umbriel	13.60	0.01	0.23	0.00
	Ariel	12.96	0.01	0.42	0.01
	Miranda	15.30	0.03	0.30	0.01
H	Titania	12.44	0.03	0.28	0.01
	Umbriel	13.37	0.03	0.21	0.01
	Ariel	12.86	0.01	0.35	0.00
	Miranda	15.14	0.01	0.26	0.00
K	Titania	12.60	0.00	0.23	0.00
	Umbriel	13.44	0.00	0.19	0.00
	Ariel	13.04	0.04	0.28	0.01
	Miranda	15.40	0.27	0.19	0.05

The geometric albedos are in good agreement with published spectra for these objects:



## Summary

This analysis has resulted in new measurements of the absolute magnitudes and geometric albedos of the inner satellites of Uranus. These values are in good agreement with previously published values, but with small experimental uncertainties.

## Acknowledgements

I am indebted to the NASA / ASEE program, and those who make it a reality, for providing me with two summers of intense intellectual stimulation. It is not an exaggeration to say that this program has reinvigorated my research program and interests. I would also especially thank Dale Cruikshank and Yvonne Pendleton, my NASA colleagues, for their help and support.

59-91

1998 - NASA-Stanford Summer Fellowship  
Final Report

415337

**The Mars Gravity Simulation Project**

Dr. Gene Korieneck, Faculty  
College of Health & Human Performance  
Oregon State University

360078

31

**Introduction** Human beings who make abrupt transitions between one gravitational environment and another undergo severe disruptions of their visual perception and visual-motor coordination, frequently accompanied by "space sickness." Clearly, such immediate effects of exposure to a novel gravitational condition have significant implications for human performance. For example, when astronauts first arrive in Earth orbit their attempts to move about in the spacecraft and to perform their duties are uncoordinated, inaccurate, and inefficient. Other inter-gravitational transitions for which these difficulties can be expected include going from the 0 g of the spacecraft to the .16 g of the Moon, from 0 g to the .38 g of Mars, and from 0 g back to the 1.0 g of Earth.

However, after astronauts have actively interacted with their new gravitational environment for several days, these problems tend to disappear, evidence that some sort of adaptive process has taken place. It would be advantageous, therefore, if there were some way to minimize or perhaps even to eliminate this potentially hazardous adaptive transition period by allowing astronauts to adapt to the altered gravitational conditions *before actually entering them*. Simultaneous adaptations to both the altered and the normal gravitational environment as a result of repeatedly adapting to one and readapting to the other, a phenomenon known as dual adaptation.

The objective of the Mars Gravity Simulator (MGS) Project is to construct a simulation of the visual and bodily effects of altered gravity. This perceptual-motor simulation is created through the use of: 1) differential body pressure to produce simulated hypo-gravity and 2) treadmill-controlled virtual reality to create a corresponding visual effect. It is expected that this combination will produce sensory motor perturbations in the subjects. Both the immediate and adaptive behavioral (postural and ambulatory) responses to these sensory perturbations will be assessed. The following questions pertaining to adaptation, Balance and Locomotion will be asked:

**Scientific Questions Relating to Adaptation**

- What happens to gait and visually open-loop walking accuracy at the transition point between two different (simulated) gravitational environments? Transitions

will include: (1) 1 g/.38 g, (2) 1 g/.17 g, (3) 1 g/1.5 g, and (4) the reverse transition for each of these.

- Does repeated alternation between two simulated gravitational conditions result in "dual adaptation."
- If dual adaptation is found, what are its necessary and sufficient discriminative cues?
- What are the optimal adaptation-training regimens for adaptation (and dual adaptation)?

#### Scientific Questions Relating to Balance

- What is the effect of unloading the body (in the LBPP) on posture and postural sway?
- What is the effect of bodily unloading on posture and postural sway compared with and without the concomitant presence of a static visual field?
- What is the effect of bodily unloading on posture and postural sway compared with and without bodily perturbations (e.g., raising the head)?

#### Scientific Questions Related to Locomotion

- What are the most metabolic, kinetic, kinematic effecient gaits in other g's.
- What are the transition points for these gaits.
- What adaptive changes occur in walking gait and accuracy as the result of continued exposure to the "new" (simulated) gravitational environment?

**The Mars Gravity Simulator (MGS)** When using the MGS, the subject walks on the treadmill, unloaded by a differential pressure device, while viewing a virtual world that is caused to move toward him/her at a rate determined by the subject's walking speed and a VE constant set by the gravitational condition being simulated. In short, the subject has the bodily and visual experience of walking through a novel gravitational world. A more in depth discussion of the 3 components of the MGS follows.

**The treadmill** Several treadmills will be used but the most experimentally promising is a motor-driven treadmill that utilizes an infrared sensor that detects advances or retreats in walking position. The speed of the treadmill is adjusted accordingly in order to approximately cancel out such changes thus maintaining the walker's location in space relatively constant.

**Differential Pressure Device** A differential pressure device that the subject wears and which loads or unloads the body by an amount that duplicates the loading experience caused by a designated gravitational condition, such as the .38 g of Mars. Current work at NASA Ames Research Center involves the use of the current version of the LPBB device

and the design of the next generation of LBPP device. Three possibilities are currently being explored:

- (1) Mars Skirt, lower-body positive pressure bag,
- (2) Mars Hat, upper-body negative pressure bubble
- (3) Mars Pants, lower-body positive pressure suit.

All three of these alternative devices unload the body by an amount proportional to the pressure differential, causing the wearer to feel and to ambulate as if they were in a hypogravity environment. The lower-body positive pressure 'Skirt' is currently implemented and being used in pilot testing.

The upper-body negative pressure bubble, the 'Hat', is an attempt to provide for more subject movement. In this design the subject is unloaded by providing a negative pressure differential between the upper and lower body. The negative pressure bubble moves fore and aft with the walking subject.

The third device, referred to as 'Mars Pants', is being developed as a part of the ongoing Mars Gravity Adaptation Project. The unique characteristic of this generation of the LBPP is that it is implemented as a pair of pants. As such it is much easier to get in and out of and affords free walking as opposed to walking on a treadmill or other mechanical constraint.

**Virtual Environment** A dual Pentium computer running WindowsNT creates a virtual world that is presented on a very large screen which covers most of the subject's visual field and should give a strong sense of immersion and forward motion during walking. The virtual world is rendered as a Martian valley and is linked to the walking of the subject. As the subject walks, the VE changes in a way that convinces the subject that he/she is walking into the valley with each step taken.

**Applications** In addition to providing the adaptation that will make these astronauts ready to perform appropriately as soon as they land on the Red Planet, it will afford them the physical exercise they need and to provide it in such an interesting and motivating manner that they are more likely to comply with the stringent exercise regimens recommended for counteracting the debilitating physical and physiological effects of chronic exposure to microgravity that would otherwise occur.

PROPOSED WIND TURBINE AEROELASTICITY STUDIES  
USING HELICOPTER SYSTEMS ANALYSIS

20-44

415340

Samaan G. Ladkany Ph.D., P.E, Professor of Civil  
Engineering, University of Nevada Las Vegas

3600 87

NASA-ASEE-STANFORD Summer Fellowship  
Final Report

31.

INTRODUCTION. Advanced systems for the analysis of rotary wing aeroelastic structures (helicopters) ,are being developed at NASA Ames by the Rotorcraft Aeromechanics Branch, ARA [7,9].The research has recently been extended to the study of wind turbines, used for electric power generation.[8] .Wind turbines play an important role in Europe, Japan & many other countries because they are non polluting & use a renewable source of energy . European countries such as Holland, Norway & France have been the world leaders in the design & manufacture of wind turbines due to their historical experience ,of several centuries , in building complex wind mill structures,which were used in water pumping,grain grinding & for lumbering[5].Fossil fuel cost in Japan & in Europe is two to three times higher than in the USA ,due to very high import taxes. High fuel cost combined with substantial governmental subsidies, allow wind generated power to be competitive with the more traditional sources of power generation. In the USA,the use of wind energy has been limited ,mainly because power production from wind is twice as expensive as from other traditional sources.Studies conducted at the National Renewable Energy Laboratories (NREL) indicate that the main cost in the production of wind turbines is due to the materials & the labor intensive processes used in the construction of turbine structures. Thus, for the US to assume world leadership in wind power generation, new lightweight & consequently very flexible wind turbines, that could be economically mass produced, would have to be developed [4,5].This effort,if successful , would result in great benefit to the US & the developing nations that suffer from overpopulation & a very high cost of energy.

ADVANCED WIND TURBINE TECHNOLOGY. Wind measurements indicate that wind speed rises steadily with height above the surface layer, therefore turbines have to be mounted on posts 15 m-100 m above groundlevel.Horizontal axis wind turbines, especially those with downwind rotors, are most efficient & may have to be built mainly of fiber reinforced composite materials ,for an optimal economical performance[4,5]. Such flexible turbines & their tall supporting posts,present fluid/structure interaction problems, similar to those encountered in the studies of helicopters [1,2,8].

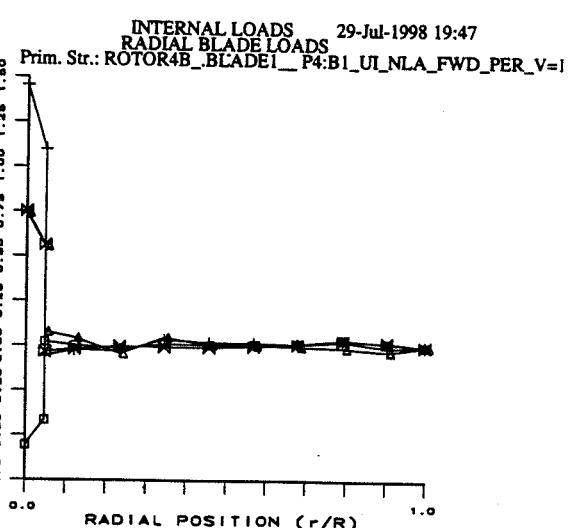
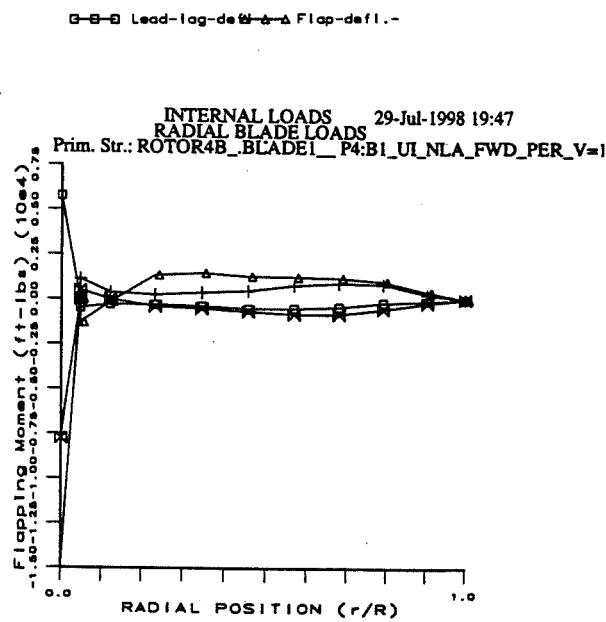
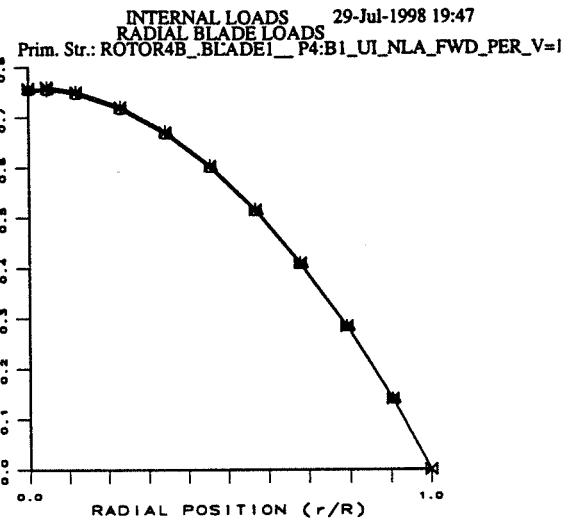
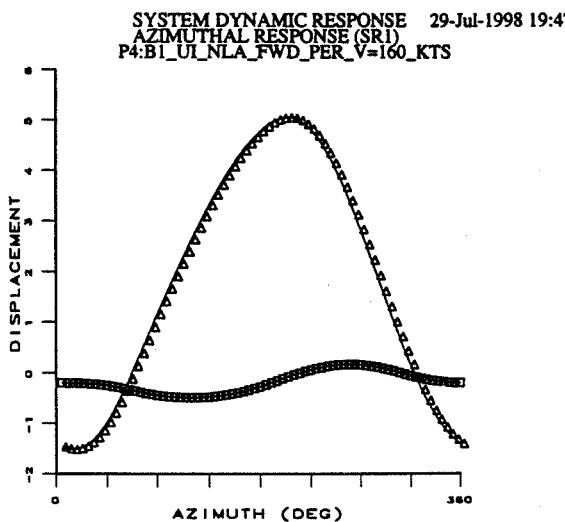
ANALYZING WIND TURBINES AS HORIZONTAL AXIS HELICOPTERS. The Rotorcraft Aeromechanics Branch at NASA Ames has developed a

comprehensive helicopter analysis system (2GCHAS) capable of simulating ,to a reasonable extent, the complex & highly nonlinear aeromechanics of helicopters. Researchers from NASA Ames & the University of Nevada,Las Vegas (UNLV) are investigating the potential applications of 2GCHAS to the analysis of flexible horizontal axis wind turbines. NREL's Phase II Turbine, which has already been subjected to extensive field testing [6],will serve as a model for our investigation, using 2GCHAS.The 3-bladed turbine has a rotor diameter of 10.06 m a hub height of 17.03 m above ground & an S809 air foil profile.Since the complete structural details of the Phase II rotor are not yet available to the researchers,an example in which the response of rotor blades, similar to a Black Hawk blade configuration,was run using 2GCHAS.The rotor model has 10 nonlinear beam elements & 62 degrees of freedom in each blade,composite construction & C81 profile. The airloads,which are defined by lift,drag & lifting moments, are extracted from standard C81 foil tables,given blade Mach numbers & angles of attack.The following figures show samples of blade internal radial loads & tip displacements.

CONCLUSIONS AND FUTURE DIRECTIONS. Substantial research is required,both analytical & experimental to advance wind turbine technology. The potential of coupling computational fluid dynamics codes to 2GCHAS is yet to be investigated.It is expected that the NASA-UNLV Research team will submit a funding proposal to NREL that addresses some critical issues in future wind turbine technology.

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G-B-B AZIMUTH = 45-DEG AZIMUTH = 90-DEG AZIMUTH = 135-DEG AZIMUTH = 270-DEG G-B-B AZIMUTH = 45-DEG AZIMUTH = 90-DEG AZIMUTH = 135-DEG AZIMUTH = 270-DEG

**Measuring Thermal Conductivity and Moisture Absorption of Cryo-Insulation Materials**

31.

Michael A. Lambert

Assistant Professor, Department of Mechanical & Aerospace Engineering  
San Jose State University

360088

**1. Introduction**

NASA is seeking to develop thermal insulation material systems suitable for withstanding both extremely high temperatures encountered during atmospheric re-entry heating and aero-braking maneuvers, as well as extremely low temperatures existing in liquid fuel storage tanks. Currently, materials used for the high temperature insulation or Thermal Protection System (TPS) are different from the low temperature, or cryogenic insulation. Dual purpose materials are necessary to the development of reusable launch vehicles (RLV).

The present Space Shuttle (or Space Transportation System, STS) employs TPS materials on the orbiter and cryo-insulation materials on the large fuel tank slung under the orbiter. The expensive fuel tank is jettisoned just before orbit is achieved and it burns up while re-entering over the Indian Ocean. A truly completely reusable launch vehicle must store all cryogenic fuel internally. The fuel tanks will be located close to the outer surface. In fact the outer skin of the craft will probably also serve as the fuel tank enclosure, as in jet airliners.

During a normal launch the combined TPS/cryo-insulation system will serve only as a low temperature insulator, since aerodynamic heating is relatively minimal during ascent to orbit. During re-entry, the combined TPS/cryo-insulation system will serve only as a high temperature insulator, since all the cryogenic fuel will have been expended in orbit. However, in the event of an aborted launch or a forced/emergency early re-entry, the tanks will still contain fuel, and the TPS/cryo-insulation will have to serve as both low and high temperature insulation.

Also, on long duration missions, such as to Mars, very effective cryo-insulation materials are needed to reduce boil off of liquid propellants, thereby reducing necessary tankage volume, weight, and cost.

The conventional approach to obtaining both low and high temperature insulation, such as is employed for the X-33 and X-34 spacecraft, is to use separate TPS and cryo-insulation materials, which are connected by means of adhesives or stand-offs (spacers). Three concepts are being considered: (1) the TPS is bonded directly to the cryo-insulation which, in turn, is bonded to the exterior of the tank, (2) stand-offs are used to make a gap between the TPS and the cryo-insulation, which is bonded externally to the tank, (3) TPS is applied directly or with stand-offs to the exterior so the tank, and cryo-insulation is applied directly to the interior of the tank.

Many potential problems are inherent in these approaches. For example, mismatch between coefficients of thermal expansion of the TPS and cryo-insulation, as well as aerodynamic loads, could lead to failure of the bond. Internal cryo-insulation must be prevent from entering the sump of the fuel turbo-pump. The mechanical integrity of the stand-off structure (if used) must withstand multiple missions. During ground hold (i.e., prior to launch) moisture condensation must be minimized in the gap between the cryo-insulation and the TPS.

The longer term solution requires the development of a single material to act as cryo-insulation during ground hold and as TPS during re-entry. Such a material minimizes complexity and weight while improving reliability and reducing cost.

## 2. Measuring Thermal Conductivity and Moisture Absorption

The low temperature thermal conductivity and moisture absorption (a concern during ground hold) must be accurately determined for candidate combined TPS/cryo-insulation materials. The fuel components liquid oxygen (LOX) and liquid hydrogen (LH<sub>2</sub>) boil at 90 K and 20 K, respectively, at sea level atmospheric pressure. However, both these fuels present a significant explosion hazard. Hence, testing will initially be performed using liquid nitrogen (LN<sub>2</sub>) and liquid helium (LHe), which boil at 77 K and 4 K, respectively, since they are both inert.

Such low temperatures are maintained in a device known as a cryostat. The cryostat for measuring thermal conductivity is illustrated in Figure 1. A specimen of the candidate TPS/cryo-insulation material (conductivity sample) is machined in two halves with cavities that, once assembled, completely enclose a copper heater block. The conductivity sample is encased in the copper sample chamber, which resembles a box. The heater block and sample chamber are both made of copper, which is highly conductive, to ensure that they remain essentially isothermal. The sample chamber assembly is sealed inside the copper gas chamber or canister, which, in turn, is sealed inside the brass vacuum chamber or canister.

During testing, the entire cryostat assembly is immersed in a vacuum insulated container, referred to as a dewar, which is filled with either liquid nitrogen or liquid helium. Both the gas chamber (inner canister) and vacuum chamber (outer canister) are evacuated to 10<sup>-6</sup> torr, then the gas chamber is back filled with dry helium gas. Power is supplied to a resistive element embedded inside the heater block, elevating its temperature. The heat generated is conducted through the heater block, into the sample, then into the sample chamber (box). The helium gas inside the gas chamber (inner canister) enhances thermal conductance across the tiny gaps between the heater block and the sample as well as between the sample and the sample chamber. The helium gas also convects heat from the sample chamber to the gas chamber (inner canister). Heat is then radiated from the gas chamber to the vacuum chamber (outer canister). The amount of helium gas inside the inner canister is regulated to control the amount of heat rejected, thereby controlling the temperature of the sample chamber assembly. The temperatures of the heater block and sample chamber (box) are measured using solid-state diodes which exhibit highly temperature dependent resistivities. The cryostat is allowed to attain steady-state conditions.

Thermal conductivity is determined from Fourier's Law of Heat Conduction, assuming thermal conductivity is independent of temperature, which is valid for relatively small temperature differences across the sample

$$\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2} + \frac{\partial^2 T}{\partial z^2} = 0$$

with the appropriate boundary conditions:

$$q_s'' = -k \frac{\partial T}{\partial x} = -k \frac{\partial T}{\partial y} = -k \frac{\partial T}{\partial z}$$

where T is temperature; k is thermal conductivity; x, y, and z are mutually orthogonal directions; and q<sub>s''</sub> is the heat flux at the inner and outer surfaces of the sample. The inner/outer surface heat fluxes, temperatures, and geometry of the sample are all known.

The cryostat for determining moisture absorption is similar to the thermal conductivity cryostat. However, the moisture absorption cryostat has vent tubes to allow humid air to be blown through the cold gas chamber to allow ice to form on the TPS/cryo-insulation sample.

### 3. Project Status

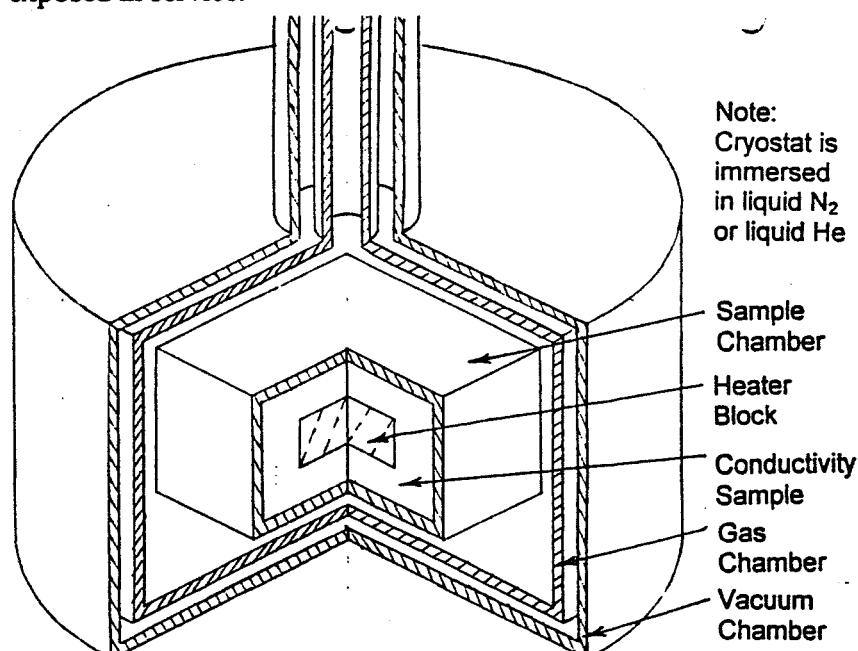
The cryostat for determining thermal conductivity has been completely fabricated, including wiring for heaters and temperature probes. It has been confirmed to maintain a tight seal under vacuum at room temperature and at 77 K. A well characterized sample material (poly-methyl-methacrylate, PMMA, a.k.a. Plexiglas) has been enclosed in the cryostat for the purposes of a shake-down test to ensure that all heaters and temperature probes are functioning properly. The shake down test will also allow for evaluation of unknown parameters, such as the magnitude of helium gas conductance across gaps in the sample chamber.

A data acquisition software package is being tailored to measure heater and temperature probe voltages. Another computer program for calculating thermal conductivity from temperature and heat power measurements has also been written and is now being validated.

Once the apparatus has been verified to operate as designed, actual candidate TPS/cryo-insulation materials will be tested at temperatures ranging from 4 K to 77 K.

The moisture absorption cryostat has been assembled and is awaiting wiring.

Once candidate materials with low thermal conductivities and moisture absorption rates at cryogenic temperatures have been identified, they will be tested in arc-jet facility. Such a facility simulates re-entry heating by directing a supersonic blast of extremely hot ionized gases at one surface of a flat sample material. The other surface of the sample will be cryo-cooled. This testing will reveal whether the candidate materials can withstand the severe temperature gradients to which they may be exposed in service.



CRYOSTAT

Figure 1.

*Final Report*

415342

**HIGH SALT DIETS, BONE STRENGTH AND MINERAL CONTENT OF MATURE FEMUR AFTER SKELETAL UNLOADING**

Michael T. C. Liang, Ph.D., ASEE Fellow  
NASA-ASEE-Stanford Colleague: Sara B. Arnaud, M.D.  
Bowling Green State University  
Bowling Green, Ohio 43403

360090

3P

**1. INTRODUCTION**

It is known that high salt diets increase urinary calcium (Ca) loss, but it is not known whether this effect weakens bone during space flight. The Bone Hormone Lab has studied the effect of high salt diets on Ca balance and whole body Ca in a space flight model (2,8). Neither the strength nor mineral content of the femurs from these studies has been evaluated. The purpose of this study was to determine the effect of high salt diets (HiNa) and skeletal unloading on femoral bone strength and bone mineral content (BMC) in mature rats.

**2. MATERIALS AND METHODS**

Mature (6 mo old) male Sprague-Dawley rats ( $n = 30$ ), body weight (BW) =  $491 \pm 14$  g, were fed normal salt (NNa), 0.26%, or HiNa, 8%, diets with restricted Ca (0.1%) and phosphorus (0.3%). The rats were divided into 4 groups: 1) controls (C) fed NNa (CNNa,  $n=7$ ), or 2) HiNa (CHiNa,  $n = 7$ ), 3) suspended (S) fed NNa (SNNa,  $n=8$ ), or 4) HiNa (SHiNa,  $n=8$ ). The S and C rats were pair fed. Water intake was given without restriction. Food and water consumption were measured daily, and body weight was measured weekly throughout the experimental period. Spaceflight model animals were suspended by their tails to keep their hind limbs  $\geq 1$  cm off the cage floor (4). The S rats were able to move freely about their cages on their forelimbs and tolerate this procedure with minimal signs of stress (2,9). At the end of the experimental period the animals were given an overdose of anesthesia, Metofane (methoxyflurane) and stored at  $-20^{\circ}\text{C}$  freezer. Both the right and left femurs were removed, cleaned off soft tissue, saturated with saline solution, covered with gauze, and then stored at  $-20^{\circ}\text{C}$  until testing. After the ultimate strength test the broken femurs were ashed. The femoral BMC (FBMC) was measured by ash weight. Femoral strength was determined using NASA's small animal torsional strength test machine with 1 %/sec internal rotation until failure. Femoral strength testing was performed with the proximal and distal ends of the femur embedded in low temperature potting material (Fusible Alloy, Bellefonte, PA) and gripped in a specially designed fixture. Maximum and minimum width of femurs were measured from the mid-shaft of the left femurs with a digimatic caliper. Femur length was measured from the greater trochanter to the distal condyles, and the humerus length from the humerus head to the distal trochlea with a digimatic caliper. A 2 x 2 ANCOVA with body weight held as covariate was used to analyze the data, and Tukey's post-hoc tests was performed to locate the source differences. Correlation coefficient analysis was used to determine the relationship between femoral ultimate strength and FBMC. A statistical significance was set at  $p = .05$ .

### 3. RESULTS

At the end of the 4 weeks experiment, BW in S rats was lower ( $p < .05$ ) than in C rats. The ANCOVA results show that 1) ultimate strength in the femurs of SNNa ( $424.6 \pm 89$  Nmm) was lower than in all other groups ( $p < .05$ ) (CNNa  $551.3 \pm 45$ , CHiNa  $576 \pm 19$  and SHiNa  $533.5 \pm 90$  Nmm); and 2) FBMC of the SNNa was slightly lower ( $p = .09$ ) than the FBMC of all other groups (Table 1). The correlation coefficient between femoral ultimate strength and FBMC of the S groups ( $n=15$ ) was  $.64$  ( $p < .001$ ) and of the entire groups ( $n=30$ ) was  $.48$  ( $p < .01$ ) (Figure 2a & 2b).

### 4. DISCUSSION AND CONCLUSION

We found the unloaded bone of rats fed high salt diets had the same mineral content and strength as the controls fed either normal or high salt diets. In contrast unloaded femurs of rats fed normal salt diets showed the expected decrease in both mineral content and strength (Table 1). Ultimate strength of mature femurs is related to the femoral mineral content (Fig 2a & 2b). These findings are consistent with the results from calcium balance studies where Navidi et al. (8) and Arnaud et al. (1,2) found that intestinal calcium absorption compensated for calcium loss in the urine in rats fed high salt diets. The mechanism as to how bone mineral content in the suspended femurs is maintained with high salt diets is unknown. We speculated the normal femoral mineral content and strength observed in the hindlimb suspended rats fed high salt diets is due to sodium driven calcium transport in the bone as well as intestine (3). Additional evidence supporting the strength test results may be performed by measuring structural geometry of the contralateral side of the femurs (5,9).

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**Table 1. Body weight and femoral mineral content, width, length, and ultimate strength in mature rats after exposed to hindlimb unloading (1998).**

Group	Control 0.26% Na <i>n</i> = 7	Unloaded 0.26% Na <i>n</i> = 7	Control 8% Na <i>n</i> = 8	Unloaded 8% Na <i>n</i> = 8
<b>Body Weight</b> Initial (g)	<b>492.86</b> (14.21)	<b>491.88</b> (13.12)	<b>492.0</b> (12.06)	<b>486.48</b> (19.65)
Final (g)	<b>488.86</b> (11.65)	<b>463.0</b> (13.32)	<b>473.0</b> (10.18)	<b>437.70</b> (20.11)
<b>Femur Mineral Content (mg)</b>	<b>580.1</b> (22.3)	<b>534.1*</b> (50.2)	<b>545.0</b> (24.5)	<b>534.50</b> (45.8)
Length (mm)	<b>41.82</b> (0.42)	<b>41.52</b> (0.54)	<b>41.52</b> (0.69)	<b>41.95</b> (0.47)
Width, max (mm)	<b>4.67</b> (0.23)	<b>4.85</b> (0.24)	<b>4.72</b> (0.16)	<b>4.75</b> (0.12)
<b>Ultimate Strength (Nmm)</b>	<b>551.3</b> (45.0)	<b>424.6**</b> (89.0)	<b>576.0</b> (19.0)	<b>533.5</b> (90.3)

Values are means and (SD);

\* $p < .05$  (t-test), compared to the control normal Na group

\*\* $p < 0.05$  (ANOVA), compared to all other groups

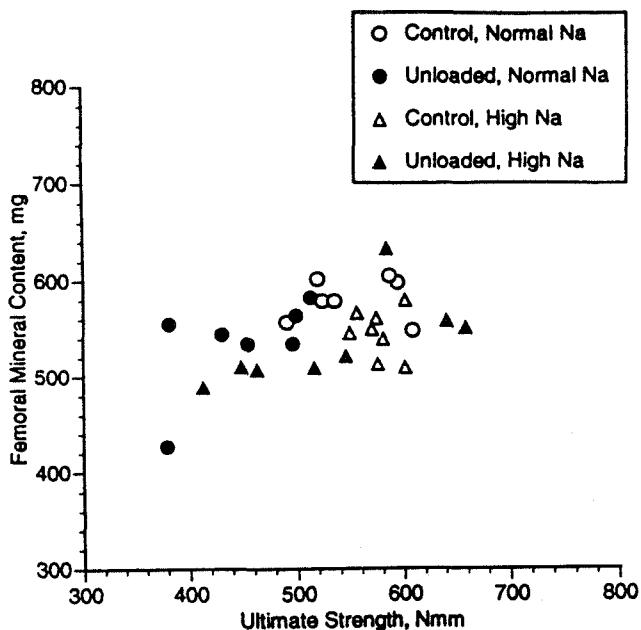


Figure 2a. Relationship between ultimate strength and mineral content of rat femurs after exposed to hindlimb unloading and high salt diets. The regression equation:  $y = 409.86 + 0.26(x)$ ,  $r = .48$ ,  $p < .01$ ,  $n = 30$ .

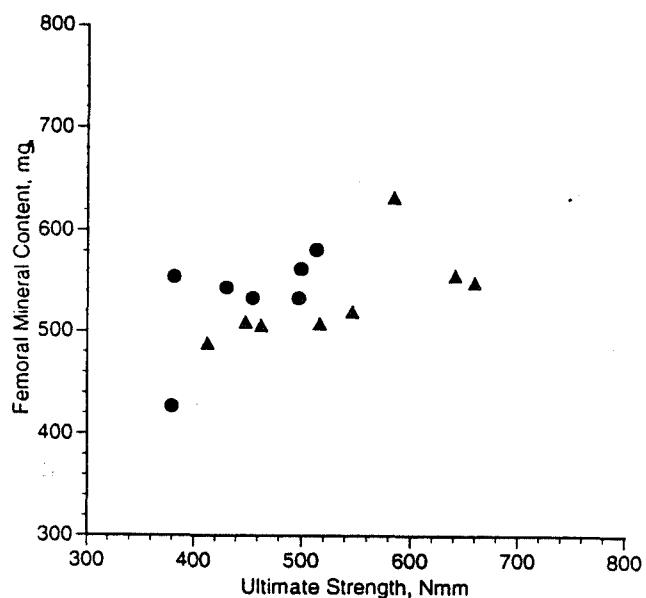


Figure 2b. Relationship between ultimate strength and mineral content of femurs in the hindlimb unloaded rats fed low or high salt diets. The regression equation:  $y_1 = 385.36 + 0.553(x_1)$ ,  $r = .62$ ,  $p < .01$  (normal salt group,  $n = 7$ );  $y_2 = 355.20 + 0.336(x_2)$ ,  $r = .66$ ,  $p < .01$  (high salt group,  $n = 8$ ).

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## 1998 NASA-ASEE-Stanford Summer Faculty Fellowship Final Report.

### Investigations of the Effects of Altered Vestibular System Function on Hindlimb Anti-gravity Muscles

Mary Sue Lowery  
 Associate Professor, Biology Department  
 University of San Diego

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360092

#### I. Introduction

Exposure to different gravitational environments, both the microgravity of spaceflight and the hypergravity of centrifugation, result in altered vestibulo-spinal function which can be reversed by reacclimation to earth gravity (2). Control of orientation, posture, and locomotion are functions of the vestibular system which are altered by changes in gravitational environment. Not only is the vestibular system involved with coordination and proprioception, but the gravity sensing portion of the vestibular system also plays a major role in maintaining muscle tone through projections to spinal cord motoneurons that control anti-gravity muscles. I have been involved with investigations of several aspects of the link between vestibular inputs and muscle morphology and function during my work with Dr. Nancy Daunton this summer and the previous summer.

We have prepared a manuscript for submission (4) to Aviation, Space, and Environmental Medicine based on work that I performed last summer in Dr. Daunton's lab. Techniques developed for that project will be utilized in subsequent experiments begun in the summer of 1998. I have been involved with the development of a pilot project to test the effects of vestibular galvanic stimulation (VGS) on anti-gravity muscles and in another project testing the effects of the ototoxic drug streptomycin on the otolith-spinal reflex and anti-gravity muscle morphology.

#### II. Vestibular Galvanic Stimulation

Since the vestibular system has neural connections to the anti-gravity muscles, it is likely that the altered input to vestibular gravity sensors during spaceflight may contribute to the atrophy seen in anti-gravity muscles. No completely effective countermeasures currently exist to prevent this muscle atrophy.

Vestibular galvanic stimulation (VGS) involves electrical stimulation of the vestibular system as current is passed across the appropriate area of the cranium to stimulate the otolith organs. Non-invasive VGS has been used in the clinical setting to evaluate human vestibular responses and has been shown to elicit muscle responses from the soleus, an important anti-gravity postural muscle in humans (3). Therefore, if non-invasive VGS can be effectively employed to stimulate the soleus and other postural muscles, then VGS shows promise as a potential countermeasure to spaceflight atrophy.

In order to evaluate the potential of VGS influence on anti-gravity muscle function, a series of pilot studies was undertaken. A previous experiment using invasive VGS on gerbils showed that stimulation for 30 minutes caused an activation of cFos in spinal motoneurons projecting to hindlimb muscles and in neurons in the hindlimb area of the motor cortex (5). cFos is a protein which is produced by cells in early stages of activation and is generally used as a marker for cells which have responded to a stimulus.

The second pilot experiment was initiated this summer and involved adapting the techniques of VGS for use in a non-invasive manner in rats. Rats have been more commonly used in spaceflight, hind-limb suspension models of microgravity effects, and centrifugation experiments. I participated in these early studies which are designed to optimize the stimulus

magnitude and duration, and the proper electrode placement and design for non-invasive VGS in the rat. Electromyography of hindlimb muscles was used to test for response to VGS. A stimulatory effect on the contralateral muscles and an inhibitory effect on the ipsilateral muscles was expected. Optimization of VGS parameters is continuing.

Once the optimal parameters for VGS in the rat are delimited, I will investigate the effects of VGS on cFos expression in the hindlimb muscles. Muscles from stimulated rats will be excised and frozen in isopentane cooled by liquid nitrogen. Cross sections of these muscles will be subjected to immunocytochemistry to localize cFos in muscle cell nuclei. An increase in cFos expression is expected in the contralateral muscles, but not the muscles ipsilateral to the stimulated otolith organ.

Demonstration of cFos expression in the muscle in response to VGS will show that not only does stimulation of the vestibular system cause stimulation of spinal motoneurons projecting to the hindlimb muscles (previously shown in gerbils), but it also directly activates muscle cells. Such activation may be important in determining levels of protein synthesis or influencing transformation of muscle fiber types; both of these functions are altered by changes in the gravitational environment and are particularly sensitive to microgravity.

If non-invasive VGS produces a stimulation of hindlimb muscle, then it may serve as an effective countermeasure for the muscle atrophy induced by spaceflight. The next step would be to evaluate the effectiveness of VGS in preventing muscle atrophy seen in hind-limb suspension, a common model for microgravity atrophy of muscle.

### **III. Suppression of Otolith-spinal Reflex by Chronic Streptomycin Treatment**

Chronic treatment of developing rats with the ototoxic drug streptomycin destroys the gravity sensing function of the vestibular system. Gravity related reflex responses in the hindlimb muscles are absent or suppressed in streptomycin treated animals. Disruption of the air-righting response and orientation while swimming are seen, as is a reduced electromyography (EMG) signal during the otolith-spinal reflex in response to free-fall (1).

Previous studies were conducted on rats which had been treated for 35 days with streptomycin. The current study was undertaken to document change in the EMG response to free-fall over the time course of streptomycin treatment to look for earlier development of these effects. Rats at 4, 8, 16, and 32 days of streptomycin treatment were evaluated for EMG response in the lumbar and thoracic back muscles and the gastrocnemius and tibialis muscles of the hindlimb during free-fall in an accelerometer device.

It is not known whether the alteration in EMG response in streptomycin treated animals is associated with changes in muscle fiber type. Hypergravity produces suppression of the EMG response during the otolith-spinal reflex similar to that seen in streptomycin treatment and also produces a transformation of type II fast-twitch fibers to type I slow-twitch fibers in the anti-gravity hindlimb muscles. In the current study the soleus, medial gastrocnemius, and tibialis muscles of the hindlimb were removed from control and streptomycin treated rats and frozen in isopentane cooled in liquid nitrogen. These muscles will be sectioned and evaluated for muscle fiber types following pH sensitive myosin ATPase staining. I was involved with the otolith-spinal reflex testing and the retrieval of muscle samples and will be involved with analyzing potential fiber type transformations in these samples.

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# A Synthesis of Fluid Dynamics and Quantum Chemistry for the Design of Nanoelectronics

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Preston J. MacDougall  
 Department of Chemistry  
 Middle Tennessee State University

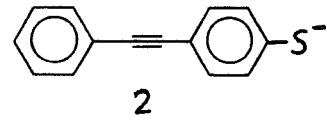
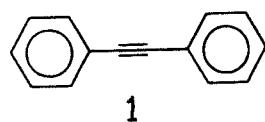
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## 1.0 Introduction

In 1959, during a famous lecture entitled "There's Plenty of Room at the Bottom" [1], Richard Feynman focused on the startling technical possibilities that would exist at the limit of miniaturization, that being atomically precise devices with dimensions in the nanometer range. A nanometer is both a convenient unit of length for medium to large sized molecules, and the root of the name of the new interdisciplinary field of "nanotechnology" [2]. Essentially, "nanoelectronics" denotes the goal of shrinking electronic devices, such as diodes and transistors, as well as integrated circuits of such devices that can perform logical operations, down to dimensions in the range of 100 nanometers [3]. The thirty-year hiatus in the development of nanotechnology can figuratively be seen as a period of waiting for the bottom-up and atomically precise construction skills of synthetic chemistry to meet the top-down reductionist aspirations of device physics. The sub-nanometer domain of nineteenth-century classical chemistry has steadily grown, and state-of-the-art supramolecular chemistry can achieve atomic precision in non-repeating molecular assemblies of the size desired for nanotechnology [4]. For nanoelectronics in particular, a basic understanding of the electron transport properties of molecules must also be developed.

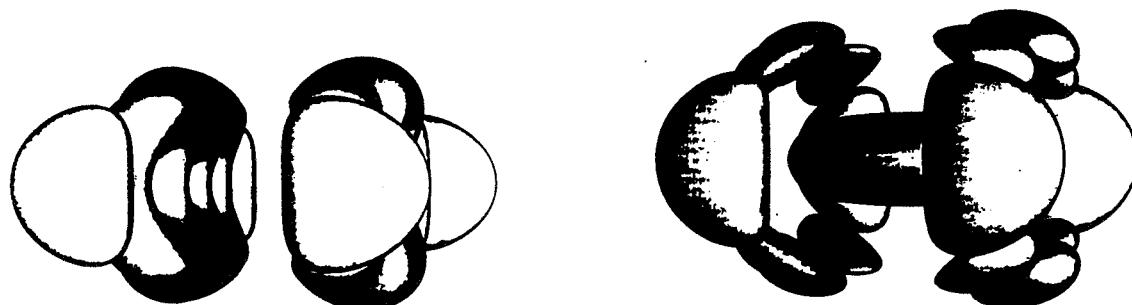
Quantum chemistry provides powerful computational methods [5] that can accurately predict the properties of small to medium sized molecules on a desktop workstation, and those of large molecules if one has access to a supercomputer. Of the many properties of a molecule that quantum chemistry routinely predicts, the ability to carry a current is one that had not even been considered until recently. "Currently", there is a controversy over just how to define this key property [6]. Reminiscent of the situation in high- $T_c$  superconductivity, much of the difficulty arises from the different models that are used to simplify the complex electronic structure of real materials. A model-independent approach has been proposed [7], that sacrifices the plentiful molecular orbitals and Bloch functions of conventional approaches, for a single three-dimensional observable quantity, the electron momentum density  $\Pi(p)$ . This quantity is simply the probability of any electron having momentum  $p$ , multiplied by the total number of electrons in the system (the position of the electron is uncertain). We have explored the utility of this new approach in providing a fundamental understanding of the electron transport properties of molecules that have been nominated as candidates for components in the design of nanoelectronics; phenylene-ethylene oligomers [8]. Some of the molecular systems that have been studied are sketched below.



## 2.0 Computational Methods and Results

NAS scientists at the Ames Research Center have developed a computer graphics package FAST (Flow Analysis Software Toolkit) for the study of fluid flow [9]. The proposed relationship between  $\Pi(p)$  and conductivity considers a molecule to be composed of stationary nuclei and an electron "fluid" [7]. Thus we have locally integrated the graphical fluid flow analysis of FAST with the *ab initio* electronic structure package Gaussian 94 [10]. Classical fluid particles permit trajectory analysis, where the positions *and* the momenta of all the particles are simultaneously defined. Quantum fluid "particles", such as electrons, can be specified only by either their positions *or* their momenta. Since molecular structure is foundational to chemistry, standard quantum chemistry techniques adopt the position representation, and Gaussian computes a many-dimensional molecular wavefunction  $\Psi$  that depends on the positions of all the electrons. The much simpler, but less familiar  $\Pi(p)$  is obtained by a many-dimensional Dirac-Fourier transformation, followed by an integration over the momentum coordinates of all the electrons but one [10,11].

As shown in Ref. [7], for a given molecular system a single postulate exhaustively partitions the continuous distribution of electron momenta into regions of laminar electron flow and regions non-laminar electron flow. In regions of  $p$ -space that are characterized by laminar electron flow, the Laplacian of the electron momentum distribution,  $\nabla^2\Pi(p)$ , is negative. Conversely, regions that are non-laminar have  $\nabla^2\Pi(p) > 0$ . It is assumed that only valence, or slow, electrons can conduct electricity when an external electric field is applied. Thus the form of  $\nabla^2\Pi(p)$  near the origin (where the electrons have no momentum) coarsely identifies the electron transport properties within the molecule. Slow electrons that have laminar flow are conducting in the presence of an applied electric field. Molecules **1** and **2** have been investigated with and without external electric fields of varying magnitudes, and directions in the case of **2**. Molecule **1** displays non-laminar slow-electron dynamics, but has undergone a transition to metallic behavior at a field strength of 0.05 au (1 au =  $5.1422 \times 10^{11}$  V/m). Molecule **2**, which possesses an "alligator clip" [3] on one end, also exhibits non-laminar slow-electron dynamics. However there is a transition to metallic behavior at a weaker field strength for the molecule that is oriented so that the field "pushes" the electrons from the alligator clip through the rest of the molecule. Isovalue surfaces, within which  $\nabla^2\Pi(p) < -0.025$  au and flow is laminar, are shown below for molecule **2** in the presence of an electric field of magnitude 0.025 au and parallel to the chain axis of the molecule. The coordinate axis that corresponds to momentum parallel to the chain axis is roughly left-right in the figures below. It is important to recall that, for example in the metallic case (right), the long cigar-like feature indicates that slow electrons with momenta parallel to the chain axis have laminar flow, but this flow is not necessarily along the axis, it could be anywhere in the molecule.



### 3.0 Conclusions and Future Directions

The electron transport properties of matter are a collective property. That is, they result from the complicated *many-body* interactions present in the system. The results obtained during the current fellowship further strengthen the exciting proposition that the salient properties, i.e. whether a system is metallic or not, can be related to a *single-particle* property  $\nabla^2\Pi(p)$ . The electron momentum density can either be calculated with quantum chemistry technology, or measured with either of the elegant condensed-matter physics techniques of Compton scattering [12] and positron annihilation [13]. Thus the results obtained so far, and those resulting from future investigations, should be of interest to a broad range of scientists.

Molecule 2 effectively behaved as a diode; current could flow only when the electric field was "on" and in a particular direction. We envision applying the above technique to larger molecules that mimic different logical devices, such as transistors. It would be more economical, especially for larger molecules, if the above method could be used with acceptable reliability when less rigorous quantum chemistry techniques are used, such as semi-empirical molecular orbital theory. The level at which the starting wavefunctions are not accurate enough can be easily gauged.

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## Thermal Property Parameter Estimation of TPS Materials

Jesse Maddren  
Assistant Professor, Department of Mechanical and Aerospace Engineering  
San Jose State University

360096

### Introduction

Accurate knowledge of the thermophysical properties of TPS (thermal protection system) materials is necessary for pre-flight design and post-flight data analysis. Thermal properties, such as thermal conductivity and the volumetric specific heat, can be estimated from transient temperature measurements using non-linear parameter estimation methods. Property values are derived by minimizing a functional of the differences between measured and calculated temperatures.

High temperature thermal response testing of TPS materials is usually done in arc-jet or radiant heating facilities which provide a quasi one-dimensional heating environment. Last year, under the NASA-ASEE-Stanford Fellowship Program, my work focused on developing a radiant heating apparatus. This year, I have worked on increasing the fidelity of the experimental measurements, optimizing the experimental procedures and interpreting the data.

### Thermal Lag Correction

Temperature measurements in test articles for transient heat transfer experiments involving TPS materials are commonly made using thermocouples. Due to thermal property mismatches and/or contact resistance between the thermocouple and the surrounding material the measured temperature response may "lag" the actual temperature response of the material. The mismatch between the volumetric heat capacity of typical lightweight, high temperature ceramic insulations and a metallic thermocouple can be an order of magnitude or more. Thus, even when perfect contact exists between an embedded thermocouple and the surrounding material, a finite temperature lag is certain because the same energy input per volume will lead to a smaller temperature rise in the thermocouple than in the insulation material. This lag effect is exacerbated when contact between the thermocouple and the surrounding material is imperfect, as it is likely to be in a typical installation (e.g., inserting a thermocouple into a drilled hole of larger diameter.)

The effect of thermal lag on thermal property estimates was investigated computationally and an algorithm was developed to systematically correct lagged temperature data during parameter estimation [1]. A two-dimensional numerical heat conduction model was used to calculate the thermal lag for a typical thermocouple installation. This numerical model incorporates the temperature dependent properties of the thermocouple and the surrounding media, includes provisions for contact resistance, and allows implementation of time varying boundary conditions. Temperature solutions computed with this model were used in an iterative manner to correct lagged temperature data so that truer property estimates could be obtained.

## **Design of Optimal Experiments**

Work has been conducted to optimize the experimental procedure and determine the conditions under which each observation should be taken in order to maximize the accuracy of the parameter estimation. Experimental factors such as the best duration of the experiment, the optimal placement of sensors and the optimal boundary conditions have been investigated.

The primary objective of the parameter estimation study is to determine the thermal conductivity, which is a strong function of temperature. The temperature dependent specific heat and the sensor location are assumed to be known or to be of secondary importance in the estimation procedure. In order to investigate the optimum experiment design for the radiant heating apparatus, temperature measurements were recorded for different heating environments. A typical temperature history is shown in Fig. 1 showing: front ( $x=0$  cm.) and back ( $x=1.27$  cm.) face thermocouple temperatures, and internal thermocouple temperatures at tc1 ( $x=0.1905$  cm.), tc2 ( $x=0.381$  cm.) and tc3 ( $x=0.762$  cm.).

Beck and Arnold [2] outline a method for determining the optimal experiment, which involves the maximization of a variable  $\Delta$ . Fig. 2 shows a plot of  $\Delta$  as a function of time for the experimental data presented in Fig. 1. The different curves represent all the possible combinations of sensors that could be used in the parameter estimation given that there are three internal sensors (it is possible that using all the sensors could yield less accurate results from the parameter estimation). It is evident from Fig. 2 that certain combinations of sensors produce larger values of  $\Delta$  and therefore increased accuracy. Also, different sensor combinations peak at different times, indicating there is an optimal experiment duration but it depends on which sensors are used in the parameter estimation. The maximum value of  $\Delta$  is achieved by using tc3 (farthest from the heated surface) alone with an experiment duration of approximately 250 sec.

## **Conclusions**

Data from the radiant heating apparatus has been analyzed using parameter estimation techniques in conjunction with the thermal lag correction and the optimal experiment results. So far the results are inconclusive and further work is in progress to eliminate possible experimental errors and improve thermal models.

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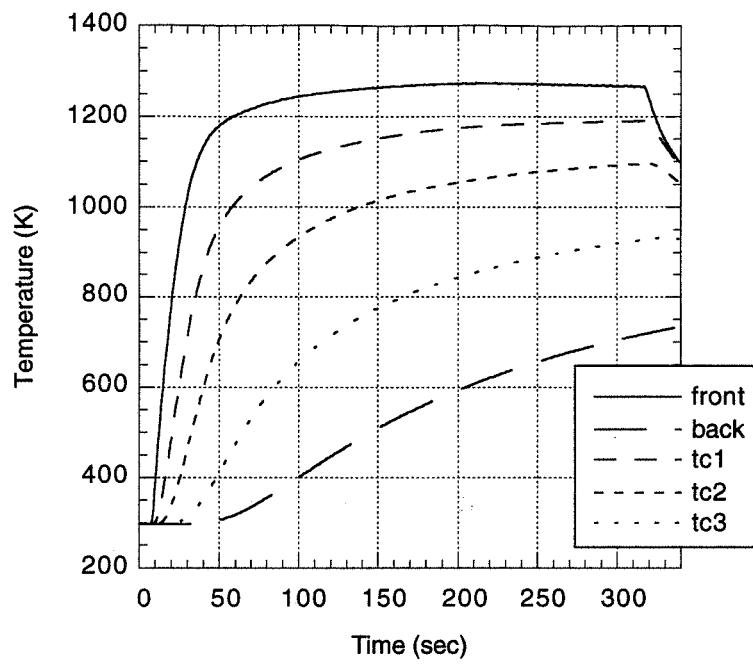


Figure 1. Temperature response

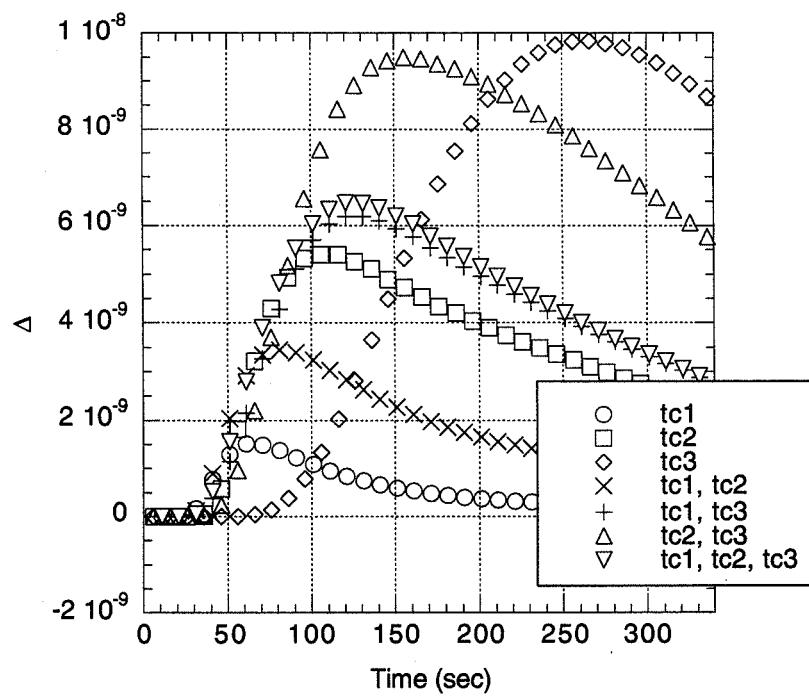


Figure 2. Optimal experiment criteria

**The Dependence of Signal-To-Noise Ratio (S/N) Between Star Brightness and  
Background on the Filter Used in Images Taken by the Vulcan Photometric Planet  
Search Camera.**

*José Mena-Werth*

*Associate Professor, Department of Physics and Physical Sciences  
University of Nebraska at Kearney*

**1. Background**

The Vulcan Photometric Planet Search is the ground-based counterpart of Kepler Mission Proposal. The Kepler Proposal calls for the launch of telescope to look intently at a small patch of sky for four year. The mission is designed to look for extra-solar planets that transit sun-like stars. The Kepler Mission should be able to detect Earth-size planets. This goal requires an instrument and software capable of detecting photometric changes of several parts per hundred thousand in the flux of a star. The goal also requires the continuous monitoring of about a hundred thousand stars. The Kepler Mission is a NASA Discovery Class proposal similar in cost to the Lunar Prospector. The Vulcan Search is also a NASA project but based at Lick Observatory. A small wide-field telescope monitors various star fields successively during the year. Dozens of images, each containing tens of thousands of stars, are taken any night that weather permits. The images are then monitored for photometric changes of the order of one part in a thousand. These changes would reveal the transit of an inner-orbit Jupiter-size planet similar to those discovered recently in spectroscopic searches.

In order to achieve a one part in one thousand photometric precision even the choice of a filter used in taking an exposure can be critical. The ultimate purpose of an filter is to increase the signal-to-noise ratio (S/N) of one's observation. Ideally, filters reduce the sky glow cause by street lights and, thereby, make the star images more distinct. The higher the S/N, the higher is the chance to observe a transit signal that indicates the presence of a new planet. It is, therefore, important to select the filter that maximizes the S/N.

**2. Data**

Two effects affect this study: (1) focusing and (2) weather. During this summer, I have concentrated on the focusing problem. I will continue with the weather half of the study back at my school.

The better focussed image has more photons falling on the smaller number of pixels on the CCD. The better focussed image also produces the smallest star images as determined by measuring their full width at half maximum (fwhm). The image processing program used is call Mira. Mira's aperture photometry calculates the S/N, fwhm, background, and central pixel brightness.

At our disposal are four filters: a Clear, a red (R), a visual (V), and a infrared (I) filter. A sample of a filter focusing test can be seen in Figure 1. The filter being tested is the red (R) filter which should allow more red light to reach our charged coupled device (CCD) detector while minimizing the mercury vapor glow from street lights. This test took place on 30 March 1998. For each exposure, the same star is selected near the center of the CCD frame and its S/N and fwhm are measured. Twelve images are examined in this test. The horizontal axis is the focus setting on the micrometer focusing mechanism. These are expensive devices with no backlash in the gears. The two vertical axes are S/N and fwhm.

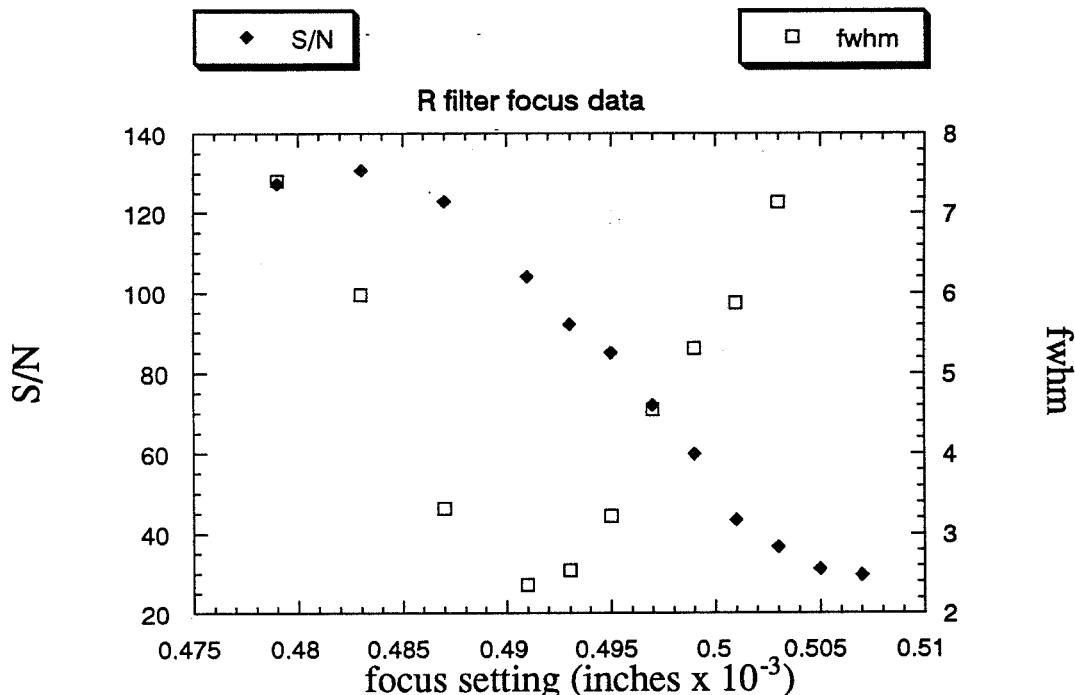


Fig. 1 — Focus test for the R filter on 30 March 1998.

As the image is more in focus two effects are noticeable: (1) the S/N reaches a maximum value while (2) the fwhm reaches a minimum value. The two events are nearly coincident. A well focussed image has stars with the highest S/N with respect to the background. A well focussed image also has the smallest star images — hence, the smallest fwhm.

The primary purpose of a focus test is to allow the observer to select the optimum focus setting. What this figure is also telling us is that the best focus setting, namely at 0.491 inch, is not necessarily the setting that will produce the highest S/N. This type of test was performed with all filters except for the Clear filter.

Figure 2 shows the dependence of four test stars on the S/N ratio when view through different filters. The clear filter maximizes the S/N better than the other filters. It is important to note that the Clear filter exposure times were 90 seconds whereas the V, R, and I filter required exposures of 180, 200, and 200 seconds, respectively. One

possibility is that the shorter exposure time for the Clear filter reduced the build up of background more effectively than the longer exposures for the other filters. Another possibility is that scattered and reflected lights from San Jose more severely affect the V, I, and R filters producing more noise.

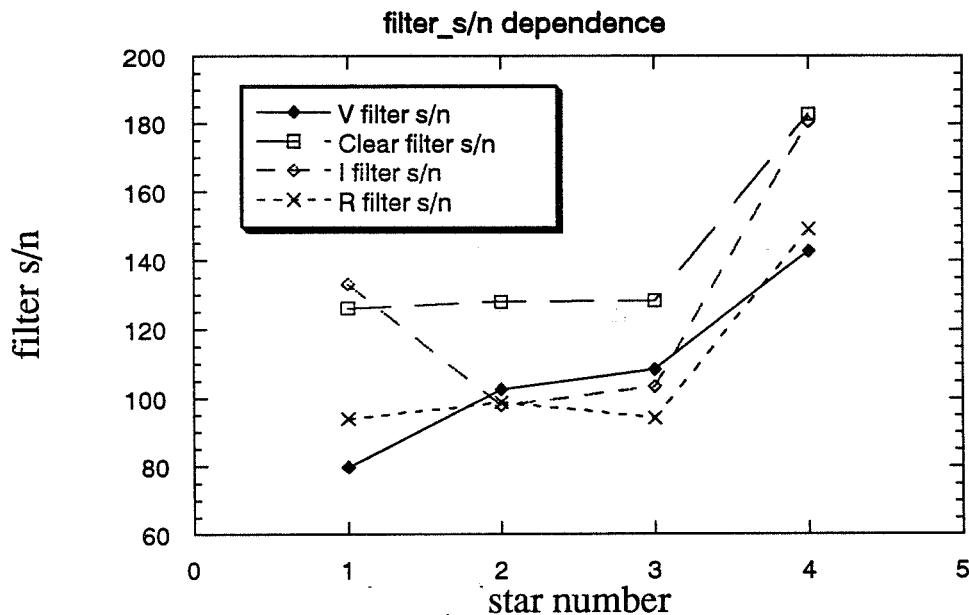


Fig. 2 — The dependence of the S/N of the same four test stars on the four filters.

### 3. Conclusion

The Clear filter was superior to the V, R, and I filters in producing star images with S/N 20% higher than the other filters. The sizes of the star images with the Clear filter as determined by their fwhm, however, are 50% larger than the star images of the R filter. The immediate recommendation is to use the Clear filter. A more conservative recommendation would be further test the behavior of the Clear filter. For example, take images of the same star field with Clear filter for different exposures; and examine whether S/N is a function of exposure time. Another suggestion is to do a focusing test for the Clear filter. Lastly, with whatever filter is chosen, a detailed focusing test should indicate whether the focus setting should be placed at a smaller value than at minimum image size in order to increase the S/N.

### 4. Unfinished Business

Still to be determined is the affect of weather on S/N for star images with different filter. Also to be determined is obtaining published photometric data on the four test stars. Lastly, a less crowded field will be studied to determine the effect of crowding on S/N.

# NASA-ASEE-Stanford Summer Faculty Fellowship 1998 - Final Report

## USE OF CONCEPT MAPPING TO ENHANCE AND UPDATE AN EDUCATIONAL CD ROM ABOUT MARS

Ellen P. Metzger, Professor, Department of Geology, San Jose State University  
NASA Colleagues: Geoffrey Briggs and Jack Farmer

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### Introduction

Last year, the Center for Mars Exploration (CMEX) at NASA Ames Research Center issued its "Return to Mars 1997" educational CD ROM. This CD, produced under the guidance of Dr. Geoffrey Briggs, summarized the on-going exploration of Mars and consisted of six sub-topics: 1) "Life on Mars?"; 2) "Mars, The Red Planet"; 3) "Human Exploration"; 4) "Robotic Missions"; 5) "Atlas and Image Processing"; and 6) "Links for Teachers". Although the CD contained a wealth of information, its format does not allow ready retrieval of information on a specific topic or concept. CMEX is working with Dr. Alberto Canas and colleagues at the University of West Florida to improve the CD's user interface through the use of concept mapping.

### Fellowship Activities

The goal of this summer's work was to contribute to the re-organization, expansion, and updating of the "Return to Mars 1997" CD. This work involved several activities: 1) becoming familiar with the nature of concept maps and their use as an organizational tool; 2) reviewing the existing CD for use as a starting point; 3) improving my own understanding of the planet Mars; 4) helping to supervise a high school and an undergraduate student; and 5) making concept maps to illustrate the geologic history of Mars.

#### 1. Use of concept maps to organize information about Mars

The fellowship work built upon a proposal by Dr. Alberto Cañas of the Institute for Human & Machine Cognition at the University of West Florida (Cañas, 1998). Dr. Cañas and his colleagues are developing software tools to enhance the effectiveness of information transfer through concept maps. Concept maps, as developed by Novak (Novak and Gowin, 1984) are two-dimensional graphic representations of a set of concepts and the inter-relationships among them (Figure 1). Concepts are arranged in a vertical hierarchy with more generally inclusive ideas at the highest levels and more specific, less inclusive concepts below them (Cañas, 1998). The relationships between concepts are shown by linking words or "propositions". For example, in Figure 1a, the concepts "Mars Exploration Strategy" and "Research Experience" are connected to form the statement "Mars exploration strategy depends on research experience".

The first step in re-organizing the "Return to Mars 1997" CD was to use concept maps as a graphic portrayal of an expert's knowledge of Mars and related topics. Dr. Geoffrey Briggs, Scientific Director of CMEX, initiated the task by constructing a number of maps about Mars and its exploration. He organized these maps into three levels from the most general (Level 1) to the most specific (Level 3) (Figure 1).

#### 2. "Mapping" the geology of Mars

As a Summer Faculty Fellow, Metzger worked to coordinate the efforts of several content-oriented teams to elaborate on Geoff Briggs's initial concept mapping efforts. Her primary content responsibility was geology. Figures 1b and 1c show a Level 2 map for "Geologic History of Mars"

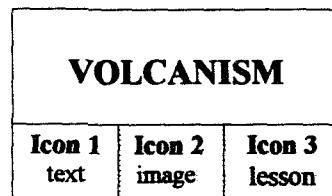
and a Level 3 map for "Martian Materials". Several other maps were produced, including a Level 2 map on "Landing Sites" and Level 3 maps on "Relative Dating" and "Volcanism".

### 3. Finding Resources to Associate with Concepts

Another goal was to collect of a variety of resources (WWW sites, images, activities for students) to be associated with individual concepts; this was done with the aid of the two students. The first step was to identify WWW links, animated sequences, and images already available on the "Return to Mars 1997" CD. We then explored the WWW and NASA publications for images and information not represented on the existing CD. A primary goal of the quest for associated resources was to include the latest data and imagery from robotic missions and current thinking about the origin and development of life on Earth and elsewhere.

### 4. Future Work

Using the concept maps produced by Metzger and others, Geoff Briggs will work with Alberto Cañas and his co-workers at the University of West Florida to devise an interface for a new CD about Mars. The use of logical linkages provided by concept maps will help the reader see important relationships and will lessen the chances of becoming "lost in cyberspace". New software developed by the Institute for Human and Machine Cognition at the University of West Florida will allow attachment of resources to a concept as "icons". For example, the concept "Volcanism" may be associated with icons as shown below, where clicking on "Icon 1" will lead to an essay comparing volcanoes on Mars to those on Earth, clicking on "Icon 2" will bring up images of Martian volcanoes, and choosing "Icon 3" will lead the reader to classroom lessons about volcanism.



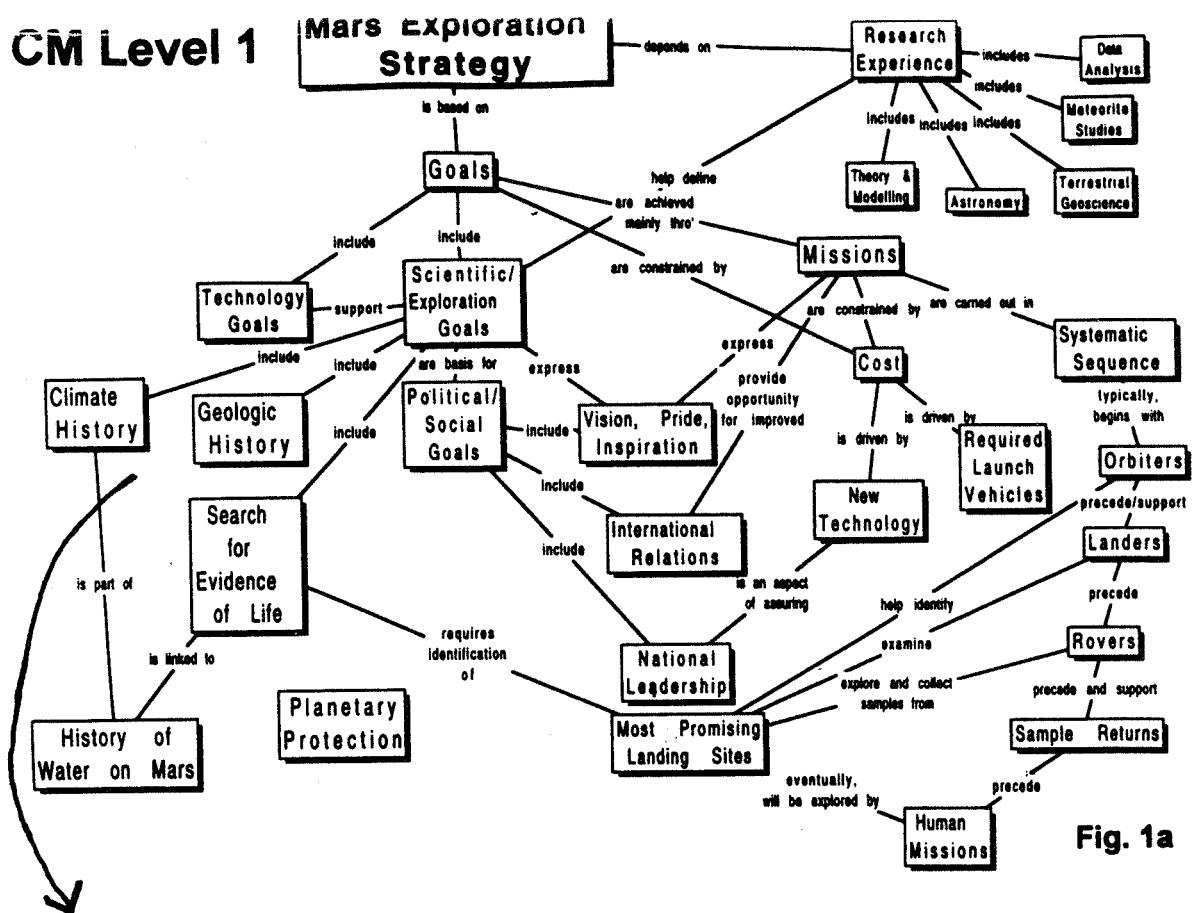
### **Additional Work with Jack Farmer**

In addition to the work done for CMEX, Metzger worked with Jack Farmer to expand upon last summer's study of carbonate deposits at Yellowstone National Park. This began with a literature search to guide collection of a new suite of rock and water samples at Hillside Springs. The new solid samples were characterized using x-ray diffraction and the water samples were submitted for geochemical analysis. The combined mineral data and water chemistry will be used to evaluate various hypotheses for why calcite is the only calcium carbonate mineral forming at Hillside Springs and as a basis for comparison with the calcite- and aragonite-precipitating system at Angel Terrace.

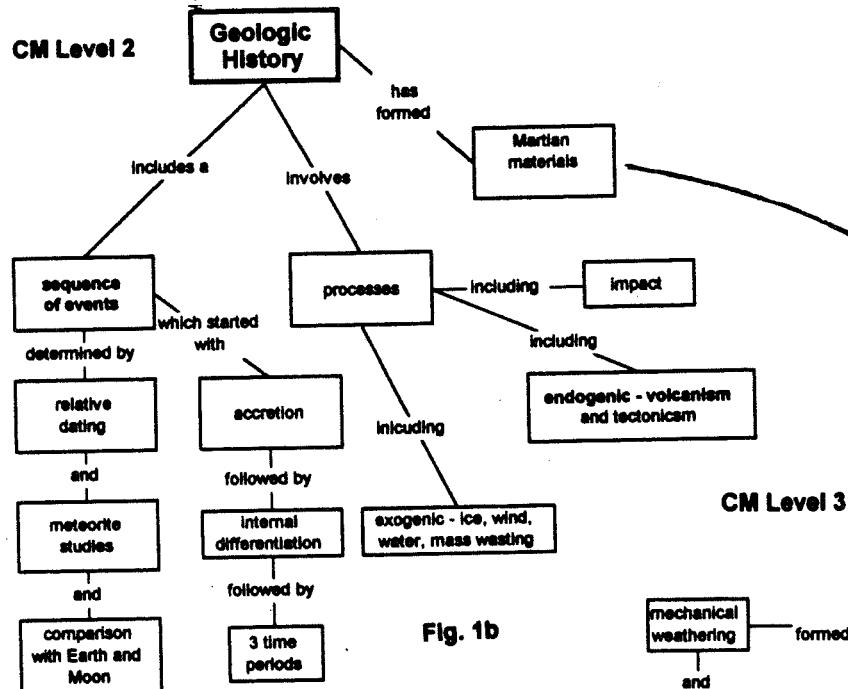
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# CM Level 1



## CM Level 2



## CM Level 3

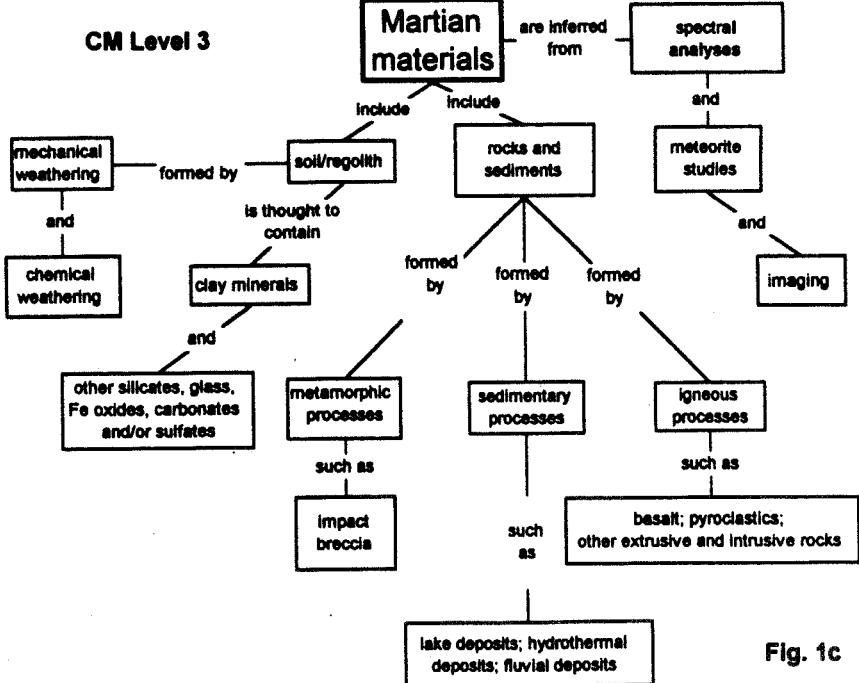


Figure 1

# NASA-ASEE-Stanford Summer Faculty Fellowship 1998 — Final Report

## DISTRIBUTED QUERIES OF LARGE NUMERICAL DATA SETS

Richard M. Nemes, Associate Professor, Computer Science Department, Pace University, New York, NY ([nemes@pace.edu](mailto:nemes@pace.edu))

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### Introduction

We have extended a previously developed high-level data model, which combines numerical quantities and meta-data into a unified hybrid model, to distributed data. An elegant query language based on SQL is extended further to allow queries against such a distributed hybrid data base. The extension is realized by allowing statements in a non-SQL programming language to be embedded in SQL view definitions.

### Summary of Previous Results

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The data that we consider here are collections of multi-valued numerical quantities on a 3-dimensional structured grid. Our previously developed hybrid model is based on the well-known relational model and its associated query language known as SQL (Structured Query Language). A query in our extended SQL is composed of clauses. The **From** clauses specifies data sets from which the chosen numerical quantities will be taken. The **Select** clause specifies numerical sets to be returned to the invoking application. An optional **Where** clause acts as a discriminator, and contains a predicate that defines the numerical set returned by the query.

Scientific data collections contain, in addition to raw numerical quantities, a smaller amount of meta-data, which describes how the raw quantities are to be interpreted. That meta-data is viewed in the now-classic relational model and combined with the numerical model just described into a hybrid model that includes both. In a hybrid data base, the relational and numerical portions exist side by side as disjoint components. Though the numerical component contains no attribute values per se, names of numerical sets (pressure, temperature, etc.) are a close counterpart and are used to play the part.

The following relations contain sample meta-data for hypothetical data sets “*wnd\_tnnl\_spc\_shttl\_jan\_1\_98*” and “*CFD\_spc\_shttl\_jan\_15\_98*”:

measurement	unit
pressure	psi
temperature	degrees K

*wnd\_tnnl\_spc\_shttl\_jan\_1\_97\_units*

calculation	unit
pressure	psf
temperature	degrees K

*CFD\_spc\_shttl\_jan\_15\_97\_units*

The following query has both relational and numerical components and shows how the two can be combined seamlessly in an elegant way. It returns identically named numerical sets with the same units. The parenthesized expressions “(w\_u.measurement)” and “(c\_u.calculation)” are the link between the relational and numerical portions. We use them to extend SQL’s usual dot notation to include the names of numerical sets that are determined dynamically, at the time the query is executed. In the above, “w\_u.measurement” and “c\_u.calculation” will both evaluate to the numerical set name “temperature” since the **Where** clause precludes pressure, one being measured in psi and the other in psf. Thus, “w.(w\_u.measurement)” and “c.(c\_u.calculation)” will evaluate to “w.temperature” and “c.temperature,” respectively.

```
Select      w.(w_u.measurement)(*), c.(c_u.calculation)()
From       wnd_tnnl_spc_shttl_jan_1_97    w,
          CFD_spc_shttl_jan_15_97   c,
          wnd_tnnl_spc_shttl_jan_1_97_units  w_u,
          CFD_spc_shttl_jan_15_97_units  c_u
Where      w_u.measurement = c_u.calculation and w_u.unit = c_u.unit
```

## Distributed Data Sets

We now address the main issue considered in this research, namely, distributed data sets. We consider data sets that are geographically distributed, yet accessible over a computer network. Queries are allowed to reference these remote data sets just as if they were locally resident. Our technique, in essence, provides a syntactic and semantic "hook" into the existing SQL mechanism for whatever protocol access technique the specifier desires, be it SQL++, JAVA, HTML, SOCKETS, UUCP, TCP/IP, TELNET, etc. Thus, in our approach we make no commitment to any particular protocol or view of the network.

Our approach is inspired by the way SQL queries can be embedded in a high level language application program and by the **Create View** mechanism of SQL.

### Views

A "view" in the relational model is a virtual relation, i.e., a relation composed of portions of one or more actual relations. Queries reference views in exactly the same way that actual relations are referenced. Thus, queries through views are transparent to the application; the application is unaware that the relation does not exist in the data base as a permanent table. The definition of a view resides in the Data Dictionary, and is accessed whenever the view name is referenced. At that time, the system executes the definition to create the virtual table, which exists only temporarily, for the duration of time that the referencing query executes. The syntax for defining a view, named here *v*, is as follows:

**Create View *v* As any legal SQL query**

The definition of *v* is given by the SQL query shown above as *any legal SQL query*. We will use the view feature as a mechanism for hiding network access computations that must take place to make a remotely referenced data set available to the referencing query. Thus, if the referencing query reads

**Select  
From *u,v,w*  
Where**

*v*'s definition will execute, making appropriate network accesses, to make *v* available to the query shown. *u* and *w* can themselves be actual relations or views.

### Embedded SQL

Standard SQL provides two ways of accessing data. SQL statements can be used interactively, or they may be embedded in an application program written a general purpose programming language such as C or JAVA (called the host language). In the latter case, the results of the query are assigned to program variables instead of appearing on the user's screen. Since SQL syntax violates the syntax rules of every known general purpose programming language, the high level language compiler cannot handle the embedded SQL directly. Instead, the application program is processed by a precompiler before compilation proper so that embedded queries can be translated into lower level equivalents in the host language. Embedded SQL queries are set off from the rest of the application program by a pair of keywords, usually **Exec Proc** and **End Proc**, with the query appearing between them. In that way the precompiler can determine which portions of the program text are SQL statements, and thus require translation, and which are not. Consequently, a typical application program with an embedded query is structured as follows:

-----;  
-----;  
**Exec Proc**

*SQL query*

**End Proc**  
-----;  
-----;

(The lines shown as “-----;” indicate arbitrary statements in the host language.)

## Distributed Queries

The idea proposed here is an extension of the idea of embedding SQL statements in an application program written in a host language. We propose allowing host language statements to be embedded in the SQL view definition so that network access can be specified in the most natural and convenient way. Using the **Exec Proc --- End Proc** idea shown earlier, we now allow **Create View** to appear as shown earlier, or, alternatively, structured as follows:

### **Create View v As**

```
Exec name of host language  
-----;  
-----;  
End name of host language
```

The idea is that the host language statements appearing between the **Exec Proc --- End Proc** pair are executed when *v*, which is a virtual relation or data set constructed from bits and pieces of data distributed throughout the network, is referenced by a locally executing query. On execution, these host language statements retrieve the required bits and pieces of data and construct the virtual table or data set locally for the executing query. A typical example might look like this:

### **Create View v As**

```
Exec JAVA  
-----;  
-----;  
End JAVA
```

When the view definition is presented to the system, the view is compiled by the appropriate host language compiler into executable object code, which is then stored permanently in the Data Dictionary until the associated view name (*v* shown above) is referenced. Should the distribution of the bits and pieces of data that constitute *v* change, a new “**Create View v As ...**” statement can be introduced that replaces the previous one. Note that the queries that reference *v* are buffered from such changes.

Unlike standard SQL, which does not allow parametrically defined views, we acknowledge that there are cases in which parametrically defined distributed relations are useful. *v*, for example, might be the data set “CFD\_spc\_shtl\_jan\_15\_98,” a multiversion data set, each version of which resides at a different network site. Assuming the programmer wants version 5 of the data set, the **From** clause would be written

```
From CFD_spc_shtl_jan_15_98(5)
```

and the view definition, assuming that it is written in C, would be structured

### **Create View CFD\_spc\_shtl\_jan\_15\_98 As**

```
Exec C (SQL_int version #)  
  
switch (version #) {  
    ----- /* various ‘cases,’ one for each version */  
}  
  
End C
```

ENANTIOMERIC EXCESSES OF ACID LABILE AMINO ACID PRECURSORS OF THE MURCHISON METEORITE.

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Sandra Pizzarello

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Department of Chemistry and Biochemistry, Arizona State University, Tempe AZ 85287.

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ABSTRACT

Amino acids present in carbonaceous chondrite are extracted in water in part as free compounds and in approximately equal part as acid labile precursors. On the assumption that they would be free of contamination, the precursors of two Murchison amino acids that have terrestrial occurrence, alanine and glutamic acid, have been targeted for analysis of their enantiomeric ratios. Pyroglutamic acid, the precursor of glutamic acid, was found with an L-enantiomeric excess comparable to that of the free acid, while alanine's precursor, N-acetyl alanine, appears approximately racemic. Also  $\alpha$ -imino propioacetic acid, a proposed end product of alanine synthesis in the meteorite<sup>12</sup>, was analyzed and found racemic.

INTRODUCTION

Since its fall in 1969 the study of the Murchison meteorite, a CM2 Chondrite, has provided a record of chemical evolution unequaled in the natural world. It has been found to contain abundant soluble organic compounds whose nature suggest an abiotic origin. Within the complex suite of organics that distinguishes these meteorites, amino acids appear of particular interest to the study of origins of life. While displaying the extensive heterogeneity of abiotic syntheses and the isotopic enrichment of interstellar molecules, they are also remarkably similar, often identical, to those found in terrestrial organisms. Recently small L-enantiomeric excesses have been found for some amino acids from water extracts of both Murchison<sup>1</sup> and the Murray<sup>2</sup> meteorites, suggesting an intriguing new correlation between these meteoritic compounds and their chiral biological counterparts. These studies focused on amino acids of unknown occurrence in the biosphere, and measured significant L-excesses for an homologous series of meteoritic enantiomeric  $\alpha$ -amino acids containing an  $\alpha$ -methyl substituent.

Chiral amino acids having both biological and meteoritic occurrence have been analyzed, but so far results have been considered inherently tainted by the possibility of terrestrial contamination. Shortly after the fall of the meteorite, Murchison amino acids' enantiomeric ratios were first determined by Kvenvolden et al.<sup>3</sup>, who found them approximately racemic, thus establishing their indigenous nature (it should be remembered, however, that the analytical method of the time was limited from fine assessment of small excesses by low sensitivity and relatively poor chromatographic discrimination). Later enantiomeric ratios of several amino acids were analyzed by Engel and Nagy<sup>4</sup>, Engel et al.<sup>5</sup>, and Engel and Macko<sup>6</sup>, and L-excesses were found for both alanine and glutamic acid, two protein amino acids. The first study was criticized by Bada et al.<sup>7</sup>, on the ground that the authors had used a near surface sample at risk of terrestrial contamination, while the latter was recently disputed by Pizzarello and Cronin<sup>8</sup> on the basis of insufficient chromatographic resolution.

Terrestrial contamination is clearly shown in old Chondrites falls, where it is recognizable as a suite of protein amino acids of fairly constant composition and relative amounts. It always include serine, threonine, tyrosine and phenylalanine not seen in uncontaminated samples. The suite, in its totality, has always been considered diagnostic.

Some Murchison samples, however, have shown a different behavior of the assumed contaminants, with regard to their enantiomeric L-excesses. For example a study of Murchison powders obtained by drilling an approximately round stone from the inside toward the center, in regular increments of three millimeters, showed that while the outermost powder gave L-excesses of all the protein amino acids, in the interior only the D/L ratio of glutamic acid remained low<sup>9</sup>. Four other measurements of glutamic

acid and alanine from different interior samples has given similar results. On the possibility that otherwise significant values of L-excesses in meteoritic amino acids would be disregarded on the sole consideration of terrestrial contamination, the study reported here has aimed to circumvent its possible effects, by targeting for enantiomeric analyses the amino acid precursors of a Murchison water extract, either directly when possible, or through the analyses of amino acids yielded upon acid hydrolysis.

## MATERIAL AND METHODS

A 45 g interior sample of the Murchison meteorite ( Arizona State University, Center for Meteorite Studies ) was crushed on a glass mortar and the powder extracted with water, at 25°, for 46 h with stirring and intermittent brief sonifications. After centrifuging and decanting from the powder, the extract was concentrated, acidified and applied to a cation exchange column for desalting. The ammonium hydroxide eluate, containing the basic compounds and the free amino acids, was dried and derivatized for Gas Chromatographic analyses. The water eluate, containing the neutral and acidic components of the extract was further fractionated on an anion exchange column, to separate subgroups of compounds of different anionic strength. Analyses were performed on a Hewlett-Packard Gas Chromatograph - Mass Spectrometer (5989-5179A) using a chiral fused silica capillary column (Alltech, Chirasil-L-val). The amino acids were analyzed as their N-trifluoroacetyl-O-isopropyl esters, while the precursors as isopropyl esters.

## RESULTS AND DISCUSSION

The results of the enantiomeric analyses of selected Murchison amino acids released from hydrolysis of precursors is shown in Table 1, as percent of L-enantiomeric excess.

TABLE 1

**L% Enantiomeric excesses of selected free and precursor-bound amino acids  
from the Murchison meteorite**

amino acid	occurrence	free	from precursors			
			Hydrolysis			
			strong	—	mild	
Alanine	protein	16.0	46.2	41.0	40.1	16.8
Glutamic a.	protein	30.6	60.2	60.2	60.6	53.2
α-amino adipic a.	non prot.	7.6	19.0	14.2	13.6	10.2
α-amino butyric a.	non prot.	not sig.	not sig.	not sig.	not sig.	—

Besides alanine and glutamic acid, α-amino butyric acid and α-amino adipic, less common non protein amino acids, were chosen for comparison. The hydrolytic conditions varied from those required for hydrolysis of proteins ( 6N HCl at 100° for 24 h ), to increasingly milder ones ( 6N HCl at 90° for 1h, 3N HCl at 80° for 4h and 0.5M acetic acid at 100° for 20 h ), that would have sufficed for hydrolysis of

carboxy lactams and N-acetyl derivatives of the amino acids found in the meteorite<sup>10</sup> but are too mild for the full break-down of possible contaminating terrestrial protein. The enantiomeric excesses found were very similar for all the hydrolyzed samples, except for the mildest conditions where the ratios were equivalent to those of free amino acids. Except for  $\alpha$ -amino buryric acid they are quite high. L-excesses for the free amino acids were lower, but still larger than the ones determined for indigenous amino acids, contradicting previous results of nearly racemic alanine. Upon finding L-excesses for protein amino acids the first assumption, and the assumption to be disproven, is that they are due to contamination. The data from the table do not contradict this assumption, and would be consistent with a pattern of contamination, deriving by either metabolism or low degradation of bacteria.

More conclusive results were obtained by the analyses of the two amino acid precursors: N-acetyl alanine and pyroglutamic. Pyroglutamic ( Fig.1 ) was found with a large L-enantiomeric excess of approximately 50 %, while N-acetyl alanine, although in small amount, gave near equal D- and L-peaks. The results point to a possible indigenous L-enantiomeric excess for glutamic acid found in hydrolyzed water extracts, the similar L-excesses of alanine are not supported by comparable excesses in the precursor , and suggests terrestrial contamination. This evaluation seems confirmed by the analysis of a meteoritic derivative of alanine.  $\alpha$ -imino propioniacetic acid is postulated to have been formed in the meteorite by the reaction of alanine with formaldehyde in the presence of cyanide. It was found in this study completely racemic ( Fig.2 ). The values observed for pyroglutamic acid are much larger than those reported for meteoritic  $\alpha$ -methyl substituted amino acids. This amino acid is not a major constituent of proteins, it is nevertheless a natural compound and not above suspicion of contamination . The data reported will have to be corroborated by analyses of more samples of different terrestrial histories. If confirmed they suggest the possibility of asymmetry producing planetary processes, that could have great significance toward the understanding of homochirality on earth.

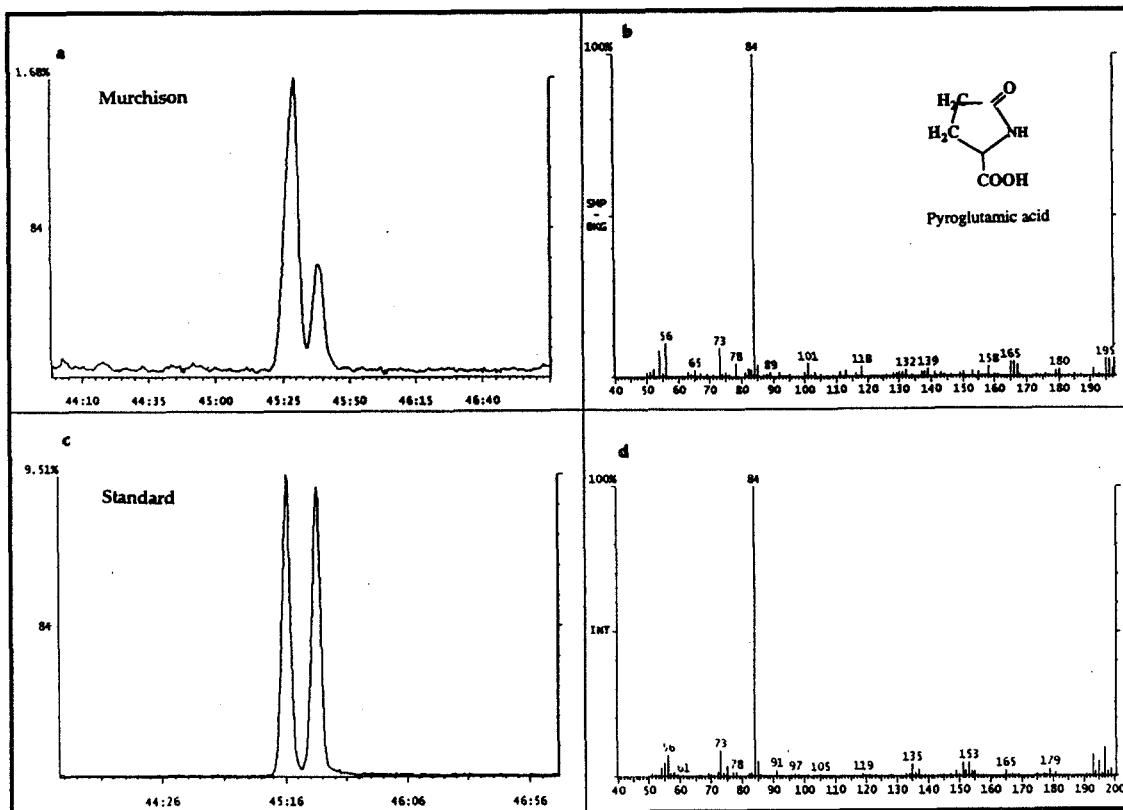


FIG.1: Single Ion Chromatogram ( m/z 84 ) and mass spectrum for pyroglutamic acid from a Murchison water extract ( a and b respectively ) and a standard ( c, d ).

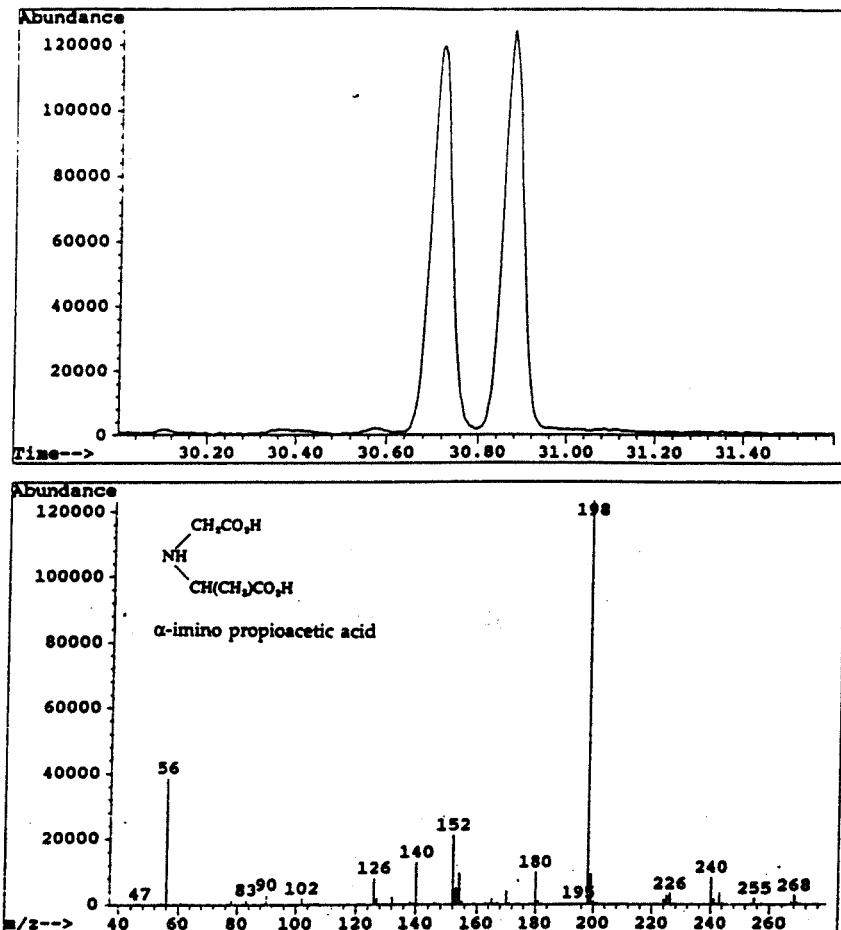


FIG 2: Single ion Chromatogram ( m/z 198 ) and mass spectrum of  $\alpha$ -imino propioacetic acid fom the Murchison meteorite.

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Research Abstract Report – NASA Summer Faculty Fellowship Program

An Integrated Tool for the Coupled Thermal and Mechanical  
Analysis of Pyrolyzing Heatshield Materials

S. W. Pronchick

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Materials that pyrolyze at elevated temperature have been commonly used as thermal protection materials in hypersonic flight, and advanced pyrolyzing materials for this purpose continue to be developed.

Because of the large temperature gradients that can arise in thermal protection materials, significant thermal stresses can develop. Advanced applications of pyrolytic materials are calling for more complex heatshield configurations, making accurate thermal stress analysis more important, and more challenging. For non-pyrolyzing materials, many finite element codes are available and capable of performing coupled thermal-mechanical analyses. These codes do not, however, have a built-in capability to perform analyses that include pyrolysis effects.

When a pyrolyzing material is heated, one or more components of the original virgin material pyrolyze and create a gas. This gas flows away from the pyrolysis zone to the surface, resulting in a reduction in surface heating. A porous residue, referred to as char, remains in place of the virgin material. While the processes involved can be complex, it has been found that a simple physical model in which virgin material reacts to form char and pyrolysis gas, will yield satisfactory analytical results.

Specifically, the effects that must be modeled include:

- Variation of thermal properties (density, specific heat, thermal conductivity) as the material composition changes
- Energy released or absorbed by the pyrolysis reactions
- Energy convected by the flow of pyrolysis gas from the interior to the surface.
- The reduction in surface heating due to surface blowing
- Chemical and mass diffusion effects at the surface between the pyrolysis gas and edge gas

Computational tools for the one-dimensional thermal analysis these materials exist and have proven to be reliable design tools.

The objective of the present work is to extend the analysis capabilities of pyrolyzing materials to axisymmetric configurations, and to couple thermal and mechanical analyses so that thermal stresses may be efficiently and accurately calculated.

The approach taken was to use an existing finite element code, and adapt its thermal analysis capability to model pyrolyzing behavior for axisymmetric geometries. As much as possible, proven thermal modeling of pyrolyzing materials from existing one-dimensional codes was retained, and adapted for axisymmetric geometries.

The MARC finite element code was selected for use<sup>1</sup>. As provided by the developers, this code performs thermal, mechanical, and coupled analyses on multi-material models. For the purposes of this work, an important feature of the code is its ability to incorporate user subroutines to adjust nodal and elemental properties during the calculation, and to define volume

and surface energy fluxes.

The thermal modeling used is based upon that developed by Acurex Corporation and implemented in the Charring Material Thermal Response and Ablation Code (CMA)<sup>2</sup>. Briefly, the model assumes that the pyrolyzing material is composed of a resin and a reinforcing material. The resin can consist of up to two components that decompose separately. The decomposition rate of each component is assumed to follow an Arrhenius-type temperature dependent reaction. Activation energies and factors in these equations are typically experimentally determined for a given material. Material properties in this model are calculated based upon the properties of the virgin and char material, and the degree to which the material has pyrolyzed.

Since the finite element code defines the configuration as arrays of elements, defined in turn, by connected nodes, performing a thermal analysis requires that appropriate energy terms be included in each element. Each element is considered as a control volume.

For in-depth elements, an energy balance shows

$$q_{\text{cond}} + q_{\text{gen}} + q_g = e_{\text{int}}$$

$q_{\text{cond}}$  = rate of energy conducted into the element

$q_{\text{gen}}$  = rate of energy generated by pyrolysis

$q_g$  = net energy increase due to pyrolysis gas flow through the element

$e_{\text{int}}$  = rate of increase in internal energy of the element

The second and third terms were included by using external subroutines to the code. The energy generated in each element is calculated based upon the decomposition rate of each material component, at the current element temperature. This rate is multiplied by the enthalpy difference between the pyrolysis gas and the solid which decomposed to find the energy. The flow term for each element is found by taking the mass flux of pyrolysis gas at each element edge, and multiplying by the enthalpy of the pyrolysis gas at the temperature of that edge. The edge temperature is taken as the average of the two bounding nodes. The mass flux at an edge is found by summing the contributions of all decomposing elements. The pyrolysis gas from each element is modeled as flowing in a radial pattern, enclosing the surface. With this model, it is possible to calculate the fraction of pyrolysis gas from that element which enters or exits all faces. These contributions are summed to produce the net mass flux at each edge.

At the surface elements, the same energy fluxes apply, but in addition, terms due to sensible convective heating, radiation, diffusion, and chemical reactions must be considered. Convective heating is described using the transfer coefficient approach, with the magnitude of heating modified by surface blowing. Energy transfer due to mass diffusion is treated by assuming a Lewis number of 1, making the heat transfer and mass transfer coefficients equivalent. No reactions are assumed between the edge gas and pyrolysis gas, and it is assumed that the wall composition is a mixture of the two, at the wall temperature and edge pressure.

As the material in each element pyrolyzes, material properties are modified to account for the degree of pyrolyzation. Density, thermal conductivity, specific heat, and emissivity are input as functions of temperature for the virgin and char compositions. The value of these properties during pyrolysis are found using a mass averaging method.

These effects were incorporated into The MARC finite element analysis code by incorporating

additional subroutines. Thermal properties of the virgin, char, and pyrolysis gas are input using an additional data file. At each iteration, the pyrolysis gas generation rate in each element, and the corresponding heat generated, is calculated. The net energy change in each element due to pyrolysis gas flow is then calculated, using a uniform radial streamline model for the pyrolysis gas flow. For surface elements, the additional surface flux terms are also included. The MARC code then calculates the new temperature field, with the time increment being adapted by the code. At the end of each increment, new values of density degree of pyrolysis are calculated for each element. Using the temperature and degree of polymerization, values of conductivity, specific heat, and emissivity are updated. The calculation then proceeds to the next increment.

At present, code validation is underway, using one dimensional cases that may be compared to existing codes.

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## NASA-ASEE Summer 1998 Final Research Review

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## Application of the Regional Atmospheric Modeling System to the Martian Atmosphere

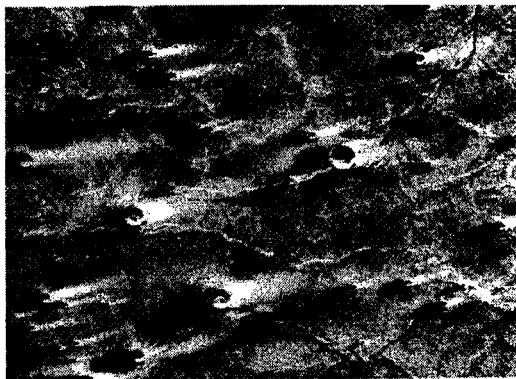
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Scot C. R. Rafkin, Ph.D.

Department of Meteorology, San José, CA 95192-0104

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The core dynamics of the Regional Atmospheric Modeling System (RAMS), a widely used and powerful mesoscale Earth model, is adapted to the Martian Atmosphere and applied in the study of aeolian surface features. In particular, research efforts focused on the substitution of Martian planetary and atmospheric properties such as rotation rate, and thermodynamic constants in place of hard-wired Earth properties. Application of the model was restricted to three-dimensional flow impinging upon impact craters, and the search for plausible wind patterns that could produce the so-called light and dark streaks downwind of topographic barriers (Veverka 1975; Thomas et al. 1984) as shown in Figure 1.



**Figure 1:** Light and dark streaks associated with craters.

Mars is perhaps more like Earth than any of the other planets, but it is still quite foreign in the context of the atmosphere. Obvious atmospheric differences are composition: nearly 100% CO<sub>2</sub> on Mars; 78% N<sub>2</sub>, 21% O<sub>2</sub>, and 1% Ar on Earth. Also, the typical surface pressure on Mars is only about 7 mb--roughly a hundred-fold smaller than on Earth. Because of the compositional differences, the thermodynamic properties also differ as shown in Table I. Atmospheric flows is influenced directly by thermodynamics properties, gravitational acceleration and rotation rate.

**Table I:** Comparison of Earth and Mars

Property	Earth	Mars
<b>Composition</b>	78% N <sub>2</sub> , 21% O <sub>2</sub> , 1% Ar	100% CO <sub>2</sub> , trace H <sub>2</sub> O
<b>Gas Constant (J kg<sup>-1</sup> K<sup>-1</sup>)</b>	287	192
<b>Specific Heat (J kg<sup>-1</sup> K<sup>-1</sup>)</b>	1004	860
<b>Gravitational Acceleration (m s<sup>-2</sup>)</b>	9.81	3.72
<b>Rotation Rate (s<sup>-1</sup>)</b>	7.294x10 <sup>-5</sup>	7.088x10 <sup>-5</sup>
<b>Planetary Radius (1000 km)</b>	6.376	3.394

Radiation, surface fluxes of heat, dust loading, the thermal tide, and water and carbon dioxide condensation are currently neglected in the model. Two proposals to NASA are now in preparation to tackle these difficult tasks. In the meantime, the model may only be realistically applied to quasi-steady radiative situations. Water condensation will produce little latent heating so the dynamical effects are

negligible. CO<sub>2</sub> condensation has considerable influence on larger than mesoscale time scales. As much as 25% of the Martian atmosphere may condense onto the polar surface of the planet (Kieffer et al. 1976; Hess et al. 1979; Paige and Ingersoll 1985), but this occurs on a seasonal scale and can be neglected in mesoscale modeling.

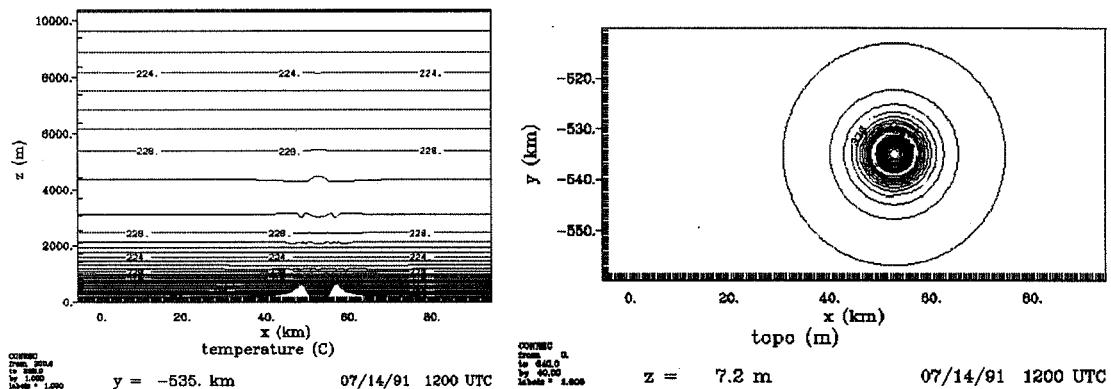
Numerous theoretical and numerical mesoscale studies of the Martian atmosphere are found in the literature--all are two-dimensional in nature. Therefore, this research represents one of the first to explore the inherently three dimensional flows associated with craters.

Thermally induced slope flows are found to be similar to those on Earth (Savijarvi et al. 1993), where the inertial oscillation and decoupling of the planetary boundary layer plays a significant role in the behavior and development of a low level jet. Ye et al. (1989) found that a typical daytime upslope flow on a moderate Martian slope was about 10 ms<sup>-1</sup> with a depth of 5km--about 2.5 times larger than those on Earth.

Of particular interest to this study is the theoretical work of Magalhães and Gerasch (1982) and Magalhães and Young (1994) who examined downslope windstorms and aeolian transport on Martian slopes. Because of the tenuous Martian atmosphere, strong winds such as those associated with windstorms are regarded as the only plausible method for depositing or eroding dust layer streaks (Murphy et al 1993).

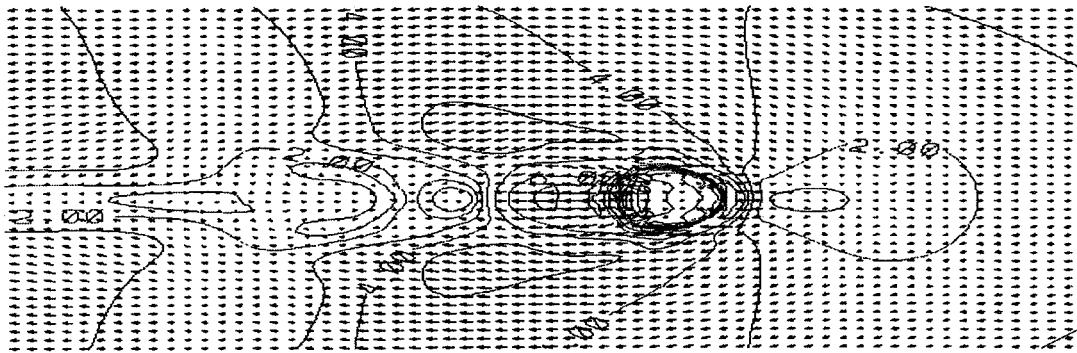
It has been assumed that small scale wind storms may also occur in the lee of craters, but the three dimensional nature of the problem makes it difficult to model analytically. The numerical analog has not yet been reported in the literature. RAMS is a suitable tool for exploring this problem.

Time permitted only one numerical experiment as most of the summer was spent re-coding, debugging and testing the model. An 8km crater (rim to rim), 800m deep and perfectly symmetrical crater was subjected to a mean east to west 10ms<sup>-1</sup> flow. A crossection through the center of the crater and topographical contour map is shown if Fig. 2.



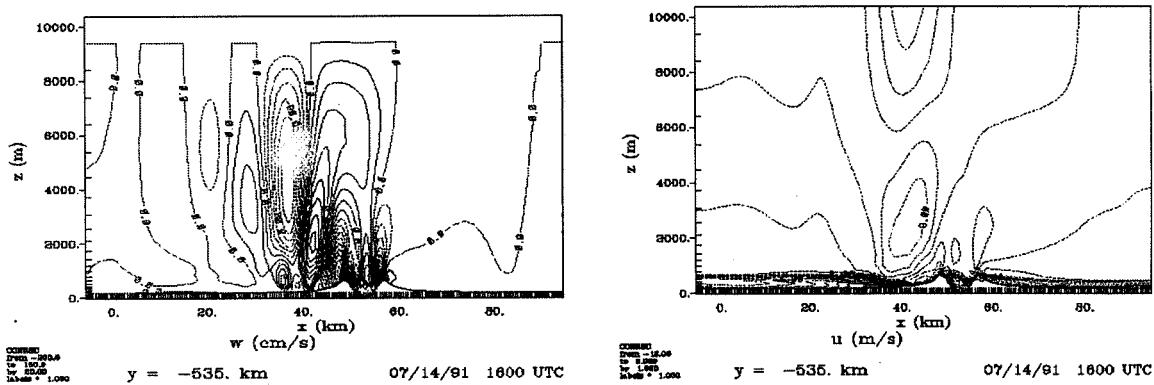
**Figure 2: Topographic map and cross-section through center of crater showing crater shape and base state temperature of the numerical experiment.**

After four hours, the flow reveals many interesting features (Fig. 3). The lower 1 km is decelerated due to surface friction. Blocking of the flow extends many crater lengths upstream of the obstacle. Downstream, the flow actually reverses and creates a flow toward the crater. Flow acceleration is apparent around the crater extended rearward in a bow wake.



**Figure 3:** Vectors and isotachs four hours into the simulation. Vectors are spaced two grid points apart (1 km). Blocking is evident many crater lengths upstream. A flow reversal is found downstream. Flow acceleration is apparent in the wake, off-center from the crater axis.

A crosssection along the crater axis also shows interesting structure in the vertical (Fig. 4). Gravity waves emanate from the crater and extend vertically to the model top, but the horizontal propagation is limited. The strongest vertical velocity is located approximately one crater diameter down stream at about 2km in altitude. The planetary boundary layer is obvious in the u wind as a strong gradient in the near surface wind.



**Figure 4:** Crossections of vertical velocity and east-west wind. Solid contours are positive and dashed are negative.

With the successful demonstration of RAMS as a tool for exploring the Martian atmosphere, future work will focus on designing meaningful experiments to explore aeolian processes. Also, funding is being sought to include other important physics besides the core dynamic model.

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1998 NASA-ASEE-Stanford Summer Fellowship  
Final Report

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## Analysis of the UV-B Regime and Potential Effects on Alfalfa

*522-43*  
**Jeffery C. Seitz**  
Department of Geological Sciences  
California State University, Hayward

*415 352*

NASA Colleagues:  
**Jay Skiles**  
**Hector D'Antoni**  
NASA Ames Research Center  
**Daniel Potts**  
Astrobiology Academy, NASA Ames Research Center

Life at the surface of the Earth, over the last 400 m.y., evolved under conditions of decreased short-wave radiation (i.e., ultraviolet) relative to solar output due to absorption and scattering by constituents (e.g., ozone, water vapor, aerosols) in the upper atmosphere. However, a significant amount of ultraviolet radiation in the range from 280-320 nm, known as ultraviolet-B radiation, reaches the Earth's surface and has sufficient energy to be damaging to biologic tissue. Natural fluctuations in atmospheric constituents (seasonal variation, volcanic eruptions, etc.), changes in the orbital attitude of the Earth (precession, axial tilt, orbital eccentricity), and long-term solar variability contribute to changes in the total amount of ultraviolet radiation reaching the surface of the Earth, and thus, the biosphere. More recently, the atmospheric release of commercial propellants and refrigerants, known as chlorofluorocarbons (CFCs), has contributed to a significant depletion in naturally occurring ozone in the stratosphere (Madronich, 1993). Thus, decreased stratospheric ozone has resulted in an increased UV-B flux at the Earth's surface which may have profound effects on terrestrial and marine organisms (Tevini, 1993; van der Leun and de Gruijl, 1993). In this study, we are investigating the effects of differing solar UV-B fluxes on alfalfa (*Medicago sativa* L.), an important agricultural crop. A long-term goal of this research is to develop spectral signatures to detect plant response to increased UV-B radiation from remote sensor platforms.

### Experimental Design

We have assembled a plant growth structure where chambers are covered with materials that filter various amounts of natural solar UV-B radiation. Polyester film is used in one chamber to block up to 98% of incoming solar UV-B radiation. In a second chamber, monoacetate film is used to reduce the incoming UV-B radiation by approximately 14% over the range of 280-320 nm. In the last chamber, plants are grown at ambient UV-B conditions as a control. Ideally, in each chamber,

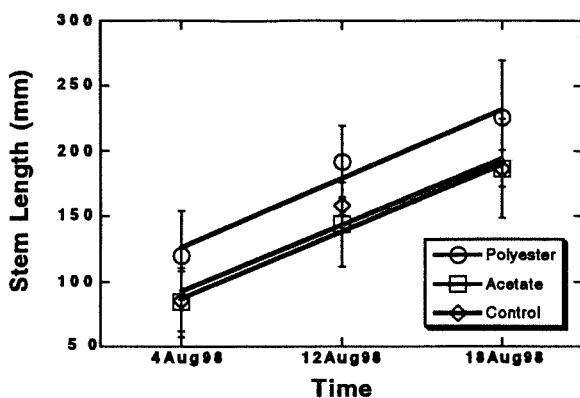


Figure 1. Total length of alfalfa stems during a three week period in three different growth chambers. Uncertainty bars indicate standard deviation of 42 individual determinations.

experiment is ongoing, differences in plant morphology are apparent between the different treatments. In Figure 1, it is apparent that the total length of alfalfa stems is greater under conditions of UV-B exclusion during a three week period. In addition, further analysis indicates that the average number of nodes per stem is greater for the plants protected from UV-B radiation. Although, these data are not conclusive, they may be regarded as indicators of increased plant production under UV-B excluded conditions. Analysis of leaf chlorophyll concentrations, within this time period, indicate no discernible trend between plants grown in the various chambers.

In order to correlate differences between plants grown in the different chambers with solar UV-B, we have measured the solar irradiance at solar noon during the plant-growth experiment. In Figure 2, a typical spectrum in the UV-B region is shown. It is interesting to note that at shorter wavelengths, attenuation by the atmosphere results in negligible radiation. However, at wavelengths greater than 300 nm, the amount of radiation reaching the Earth's surface is significant. The "kinks" that occur in the spectral curve are real and represent absorption by various atmospheric components. The wavelengths at which ozone absorbs UV-B radiation are indicated by dashed lines in Figure 2. We are attempting to correlate our measurements of solar irradiance with data obtained at various locations in the western hemisphere.

the alfalfa is subjected to similar growth conditions (visible light flux, temperature, humidity) and, thus, morphological and chemical differences in the plants in the various chambers are due to differing amounts of UV-B treatment. In this experiment, plant response to UV-B treatment is determined by measuring the leaf chlorophyll and flavonoid concentrations, plant morphology (internodal distances between adjacent petioles and the number of nodes per stem), and total biomass production. Although the

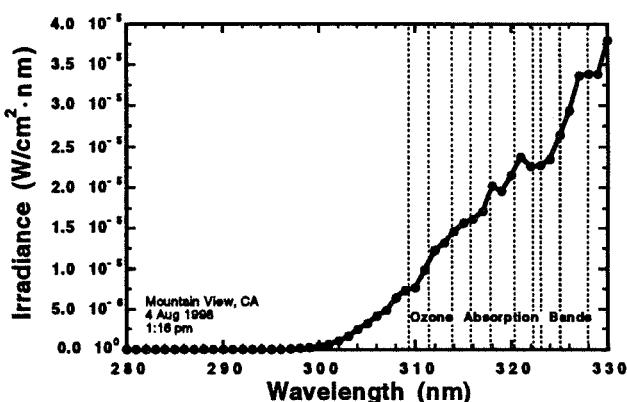


Figure 2. Solar irradiance in the UV-B region measured with an Optronics OL752 spectroradiometer. Dashed lines indicate ozone absorption bands.

## Discussion

The 1998 plant growth experiment represents the fourth year of this long-term research program. Results from previous years indicate complex response of the plant parameters to UV-B radiation during different years. In 1995, all the plant parameters indicated significant differences between plants grown in the different chambers. However, in 1996, differences between plants grown in the different chambers were negligible. During 1997, there were significant differences between the plants grown in the various chambers under different UV-B regimes. One possible explanation for this seemingly disparate behavior is that, during 1996, solar UV-B flux was reduced, relative to 1995 and 1997, such that the plants grown in the control chamber received a reduced dosage of UV-B radiation. In order to test this hypothesis, we examined UV-B measurements obtained at Davis, CA during the previous three years. In Figure 3a, the integrated daily UV-B flux is plotted for 1995, 1996, and 1997 for the Davis site during the summer plant growth experiments. In order to delineate a cumulative trend during the growing season, we plotted the summation of daily UV-B dosages in Figure 3b. Thus, Figure 3b indicates that the cumulative UV-B flux was reduced by about 12% during 1996 relative to 1995. In order to confirm this observation, we have calculated cumulative solar irradiances measured at several other locations in the western U.S. and found a similar temporal trend. This conclusion is significant in that the hypothesis was conceived by examining differences in plant growth parameters during several years and indicates that changes in solar UV-B fluxes may have profound and immediate effects on terrestrial plants and ecosystems.

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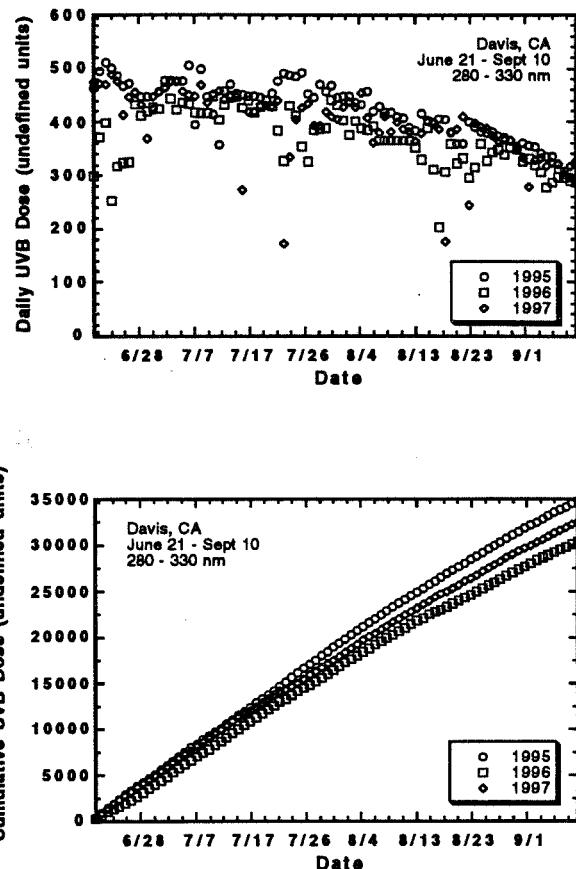


Figure 3 a&b. Daily (a) and cumulative (b) solar UV-B dosages determined for the growing seasons during 3 different years in Davis, CA. Data obtained with a pyranometer as part of the USDA UV-B network.

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## USER DIRECTED TOOLS FOR EXPLOITING EXPERT KNOWLEDGE IN AN IMMERSIVE SEGMENTATION AND VISUALIZATION ENVIRONMENT

Steven O. Senger, Ph.D, Professor,  
Department of Computer Science, Department of Mathematics,  
University of Wisconsin - La Crosse, La Crosse, WI.

523-82  
415 353

**Introduction.** Volumetric data sets have become common in medicine and many sciences through technologies such as computed x-ray tomography (CT), magnetic resonance (MR), positron emission tomography (PET), confocal microscopy and 3D ultrasound. When presented with 2D images humans immediately and unconsciously begin a visual analysis of the scene. The viewer surveys the scene identifying significant landmarks and building an internal mental model of presented information. The identification of features is strongly influenced by the viewers expectations based upon their expert knowledge of what the image should contain. While not a conscious activity, the viewer makes a series of choices about how to interpret the scene. These choices occur in parallel with viewing the scene and effectively change the way the viewer sees the image. It is this interaction of viewing and choice which is the basis of many familiar visual illusions. This is especially important in the interpretation of medical images where it is the expert knowledge of the radiologist which interprets the image.

For 3D data sets this interaction of view and choice is frustrated because choices must precede the visualization of the data set. It is not possible to visualize the data set without making some initial choices which determine how the volume of data is presented to the eye. These choices include, view point orientation, region identification, color and opacity assignments. Further compounding the problem is the fact that these visualization choices are defined in terms of computer graphics as opposed to language of the experts knowledge.

The long term goal of this project is to develop an environment where the user can interact with volumetric data sets using tools which promote the utilization of expert knowledge by incorporating visualization and choice into a tight computational loop. The tools will support activities involving the segmentation of structures, construction of surface meshes and local filtering of the data set. To conform to this environment tools should have several key attributes. First, they should be only rely on computations over a local neighborhood of the probe position. Second, they should operate iteratively over time converging towards a limit behavior. Third, they should adapt to user input modifying they operational parameters with time.

The Biocomputation Center at Ames has and continues to play a pioneering role in the 3D reconstruction of volumetric data. This technology is used to support visualization objectives in neuroscience and more recently in medical imaging and surgical planning and simulation [2,3]. Problems in visualization, segmentation and manipulation of large volumetric data sets are central

to the work of the center.

**Prior Work.** During the summer of 1997 a prototype version of this environment was developed. The software environment was built around the Fakespace Immersive Workbench and a position/orientation tracked Polhemus probe. The system presents the user with the illusion, through stereo imaging, that the data set resides on top of the table with the probe position co-located within the data set. As a background, the table displays the cross section of the data set located at the table surface. The data set is imaged using a ray-casting based volume rendering algorithm which includes a lighting model incorporating diffuse and specular highlights of high opacity material. Image reconstruction is constrained to a spherical region about the probe position. As the probe is moved through the space above the table, that portion of the data set encompassed by the sphere is rendered into view. The user controls whether the data imaged by the probe persists in the imaged scene or disappears as the probe moves by. Alternatively, instead of using the probe position to bring data voxels into view, the probe position can also be used to exclude previously imaged data from the scene. The resulting interface gives the user the illusion that they are selectively "sculpting" the data out of the volume, concentrating their attention on the regions of greatest interest.

The system supports segmentation of structures in both the ray space of the imaging model and the data space of the volume. In ray space segmentation tool statistically determines a description of the voxels in the immediate neighborhood of the probe position when a segmentation action is initiated. As the probe is moved through the data set, voxels matching the description are rendered in full or partial opacity while other voxels are rendered as transparent. The description is obtained through an iterative clustering algorithm which builds a cluster description of those voxels in the immediate vicinity of the probe as opposed to those at a greater distance. The combination of cluster description and the region traversed by the probe effectively segments structures from the data set.

The second segmentation tool operates in the data space itself. When triggered this tools also develops a cluster description of the immediate neighborhood but then uses this description to propagate a digital stain through the data set. This is a 3D analog of a 2D algorithm developed in [4,5]. As voxels are stained they are brought into full opacity. The propagation primarily moves to voxels most similar to the description but also exhibits a preference to move towards the probes current position. The stained voxels identify the segmented structure. Both of these tools fit the requirements of be locally computable, iterative and interactive. The segmented structure descriptions can be used to produce surface meshes for display and manipulation.

This work has been reported in [6]. Over the past year the environment has been reimplemented using a client/server architecture and is also capable of exploiting multiple processors.

**Current Work.** During the summer of 1998 work has focused on extending the tool collection to include tools for filtering data sets to remove noise and directly producing surface meshes interactively. Noise is a problem inherent in all data sets. In CT data noise primarily arises from shadows cast by regions which are highly x-ray opaque. This is particularly acute for visualizing soft

tissue which has a relatively low x-ray opacity. The effect is to obscure the boundaries between tissues. Ultrasound data set suffer from similar problems.

While humans viewers of such data easily disregard such image artifacts because of their expert knowledge, the artifacts carry over into the segmentation process and subsequent production of surface meshes. Signal processing and data filtering are well developed subjects but there is always a tradeoff between resolvable feature size and noise reduction. The goal of this tool is to provide an iterative mechanism for minimizing the effects of noise by allowing the user with their expert knowledge to interactively control the effect of noise removal. A prototype algorithm has been developed which satisfies the requirements of a tool for an immersive environment. Provided with a collection of cluster descriptions it iteratively adjusts voxel values in the direction of cluster centroids based on a locally computed confidence measure. The effect is self limiting but allows the viewer to control the extent of filtering so as to selectively preserve important features in the data set. The technique has proven very successful in producing clean surface meshes from CT data of a living heart which preserve significant surface vascular features.

A related problem is found in 3D ultrasound data. In this case the data set is four dimensional consisting of a volume of space imaged over successive time intervals. The specific data set studied this summer was obtained from the Cleveland Clinic and records a human mitral valve over a full cardiac cycle. While data of this kind can be filtered by standard techniques the time varying nature of the data provides a unique opportunity. In humans, movement in the visual field provides powerful queues for interpreting images. Each time sample of the 3D ultrasound data is extremely noisy and hard to interpret, but when viewed as varying over time, the eye immediately recognizes coherent structures in the data. By estimating the flow field of objects [1] within the data set and time averaging individual voxels as they move through this flow field it is possible to reduce the effects of noise. A prototype of this algorithm has been implemented and is currently under study.

Finally, there are significant advantages to directly producing surface meshes during the segmentation process as opposed to generating them from volumetric segmentation during a post processing phase. The standard technique for constructing surface meshes in a volumetric data set is to treat voxel values as the estimated data set value at the corners of cublets within the data volume. For a given threshold value the entire data set is scanned and for any cublet whose corner values straddle the threshold value a cutting plane is constructed using triangles whose vertices are interpolated points on the cublet edges corresponding to the threshold values. The collection of all such triangles forms the surface mesh. This is a global computation requiring a complete survey of the data volume.

Extending ideas from previous work, development has begun on an immersive tool to interactively produce surface meshes. Two strategies are being explored. First, the staining tool can be run in a multi-cluster mode where voxels are progressively stained into one of several clusters. For example, two cluster might represent the interior and exterior of a region respectively. The zone of competition, those voxels where the separate stains compete, defines the boundary where the surface mesh is constructed. The surface mesh can be constructed during the staining process by applying the standard technique to boundary voxels. As staining progresses, an artificial gradient field is

constructed at the boundary using diffusion techniques. The cublet cutting planes are determined by from this gradient field. This algorithm is iterative and locally computable.

The second technique under exploration is to produce surface meshes through an extrusion process. In an analogue to the staining process, a surface is iteratively constructed from an initial starting point. As the surface is extended through the volume, triangle vertices are chosen to minimize statistical differences between voxel samples on either side of the surface. This algorithm is also iterative and locally computable.

**Future Directions.** The Biocomputation Center has recently obtained a Phantom haptic feedback device. This device allows the user to obtain a sense of "touch" from the imaged data. A "touch" sense would allow the user to feel surface detail in the data. The force which the user applies could be used to bias and control the immersive tools in a variety of ways.

**Summary.** The goal of this environment is to move the expert medical knowledge of the end user into the visualization and segmentation process. By providing an intuitive way to guide the process the user is able to interactively concentrate computational resources on imaging those features of greatest value to the medical objectives.

**Acknowledgments.** This work was done while the author was a NASA-ASEE-Stanford summer fellow at the NASA Ames Biocomputation Center. The author would like to thank the director, Dr. Muriel Ross, and her staff for a supportive environment in which to perform this investigation.

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**Simulation of Ames Backbone Network**

**Hamid Shahnasser**  
Professor, School of Engineering  
San Francisco State University

**Introduction**

The networking demands of Ames Research Center are dramatically increasing. More and more workstations are requested to run video and audio applications on the network. These applications require a much greater bandwidth than data applications. The existing ARCLAN 2000 network (Figure 1) bandwidth is insufficient, due to the use of FDDI as its backbone, for accommodating video applications. Operating at a maximum of 100 Mbps, FDDI can handle only a few workstations running multimedia applications. The ideal solution is to replace the current ARCLAN 2000 FDDI backbone with an ATM backbone. ATM has the capability to handle the increasing traffic loads on the ARCLAN 2000 that results from these new applications. As it can be seen from Figure 1, ARCLAN 2000 have a total of 32 routers (5 being core routers) each connected to the FDDI backbone via a 100 Mbps link. This network serves 34 different locations by using 34 hubs that are connected to secondary routers. End users are connected to the secondary routers with 10 Mbps links.

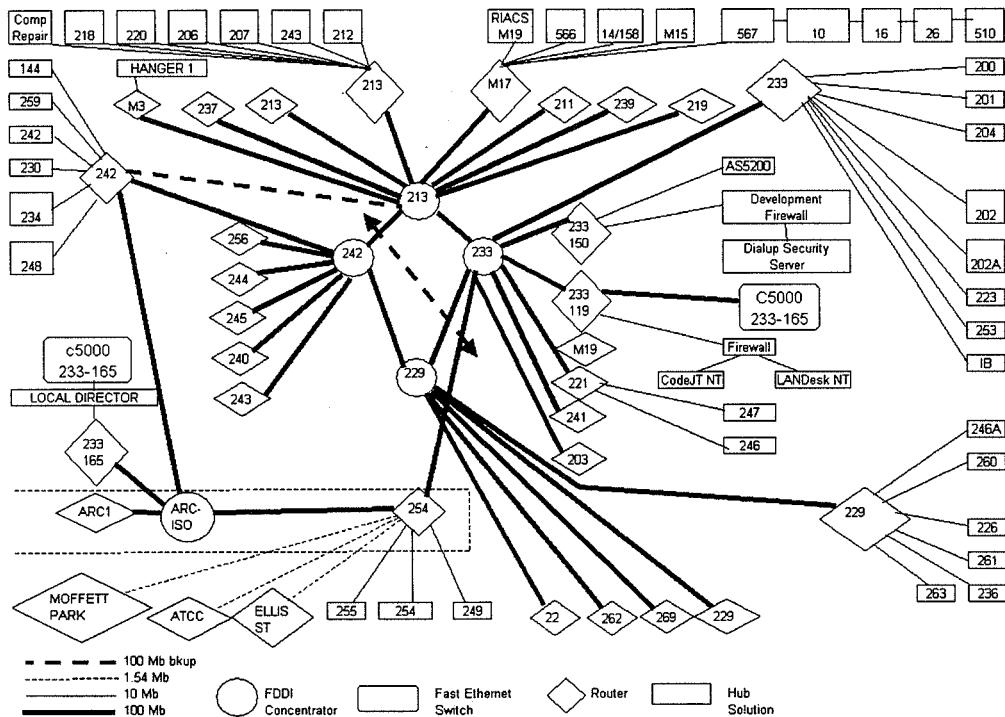


Figure 1: ARCLAN 2000 Overview

The focus of our study was: 1. To model network ARCLAN 2000 with various traffic types (FTP, Web search, audio and video) 2. Examination and analysis of the end to end delays incurred by various applications. 3. Evaluation of the simulation tool used.

We used Comnet III 1.4 software package to simulate the ARCLAN 2000 network. Comnet III is a popular network simulator developed by CACI Products Company. It is a graphical software package that allows users to analyze and predict the performance of the networks ranging from simple to very complex ones.

### Simulation study

The simplified topology of simulated ARCLAN2000 is shown in Figure 2.

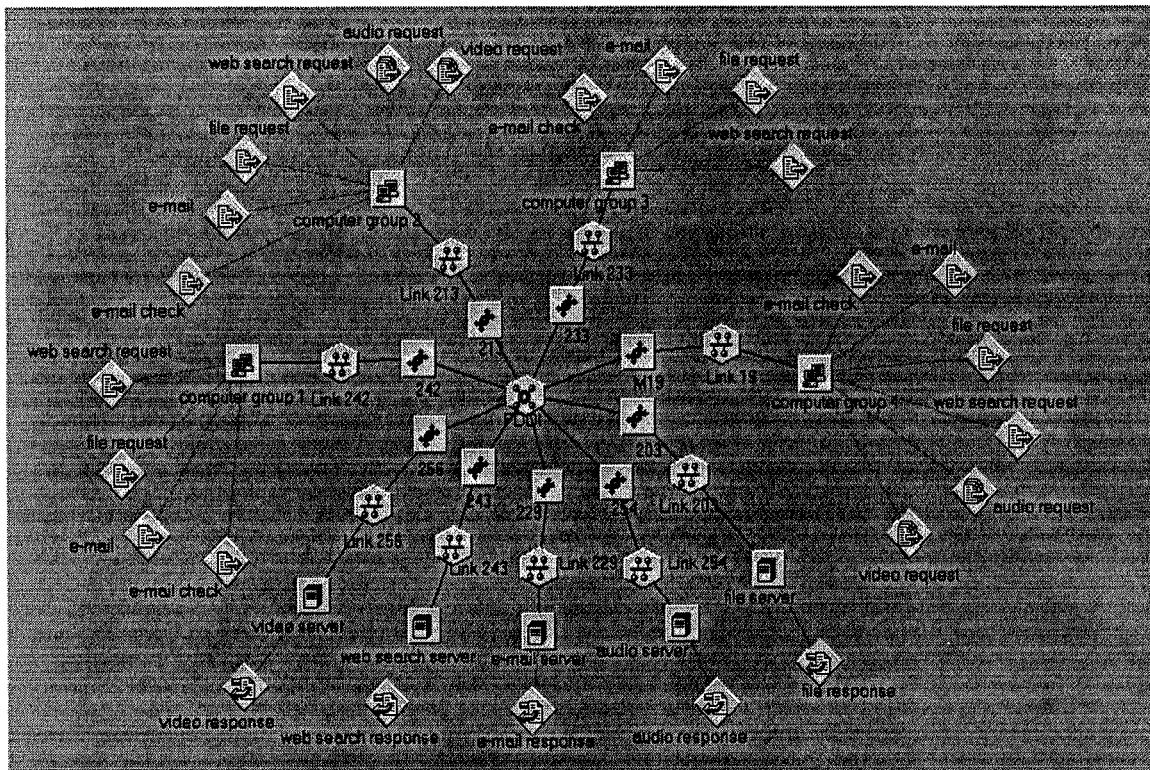


Figure 2

The parameters of each node are set to reflect the real-world network applications. 100 Mbps Ethernet connects computer groups to the FDDI backbone via routers. IP protocol is being used end-to-end. Cisco 7000 was selected for routers 242, 213, 233, M19, 254 and 299. Cisco 7010, which has optical outputs for FDDI, was selected for router 256, 243 and 203.

We attached four workstations and six computer groups to the ring. Each computer group is used to model a population of similar users connecting to a network. Increasing the numbers in computer groups results in increasing traffic load.

The size of email messages is described by a uniform distribution where the size is evenly dispersed over the range of 500 to 2000 bytes. The size of email responses is specified by a Normal distribution with a mean of 40000 bytes and a standard deviation of 10000 bytes.

The size of file responses is specified by a Normal distribution which of 100000 bytes and a standard deviation of 25000 bytes. The size of web search responses is specified with a Normal distribution, which has a mean of 200000 bytes and a standard deviation of 50000 bytes.

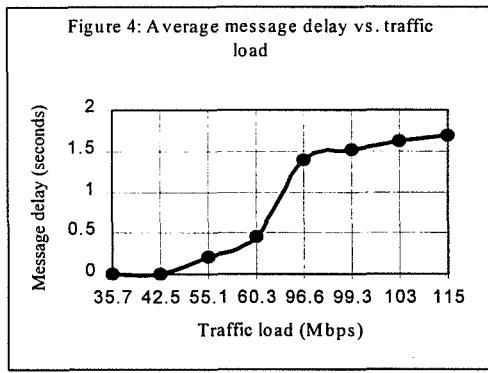
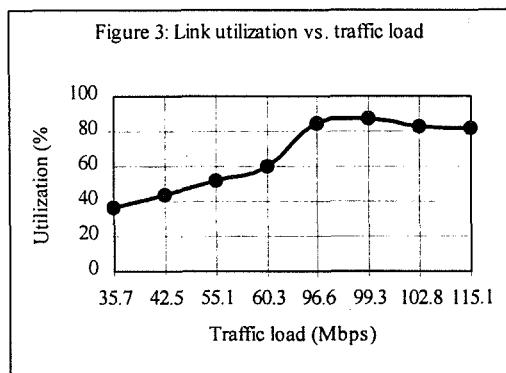
The average traffic rates for audio and video session are 176 Kbps and 17.6 Mbps respectively.

Table 1 summarizes the simulation results of the network with various traffic loads.

Table 1:

Traffic Load	Traffic Load on FDDI (Mbps)	FDDI Utilization (%)	Average Application's Delay in sec
Low	35.71	36.07	0.006
Low	42.50	43.52	0.006
Medium	55.10	52.02	0.211
Medium	60.29	60.44	0.450
High	96.61	84.48	1.393
High	99.30	87.01	1.517
Overload	102.8	82.72	1.611
Overload	115.11	81.39	1.684

As one might expected, there is almost a perfect linear relationship between traffic load and channel utilization when the traffic is less than 90 Mbps, as shown in figure 3. In the case where traffic goes beyond 100 Mbps (i.e. overload), utilization will stay close to 100% but delays are not acceptable for the particular applications any more. The delay vs. traffic load is shown in figure 4.



### Conclusions and Future Directions:

The results from this preliminary work indicates that the delays involved in users' sessions, that include video, are not acceptable for satisfying the quality of service required for video. It also indicated that the end-to-end delay of more than one second are observed for high network traffic loads. This work was also carried out to evaluate the CACI software package, for possible further in-depth simulation study of ARCLAN 2000, and the results indicate that more detailed and useful network insights could be obtained by the inclusion of this package in Ames network design and management tools. A very useful follow up to this work would be to simulate the ATM and Gigabit Ethernet, the alternatives currently being considered at Ames, for improving the existing network.

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NASA-ASEE-Stanford Summer Faculty Fellowship 1998 - Final Report

Rossby Waves in the Protoplanetary Nebula

D.P. Sheehan, Dept. Physics, USD, San Diego, CA 92110

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Fluid waves and instabilities are considered critical to the evolution of protoplanetary nebulae, particularly for their roles in mass, angular momentum, and energy transport (Adams and Lin, 1993). A number have been identified, however, notably absent, is an influential wave commonly found in planetary atmospheres and oceans: the planetary Rossby wave (PRW). Since, in the Earth's atmosphere, the PRW is of primary importance in shaping large-scale meteorological phenomena, it is reasonable to consider whether it might have similar importance in the protoplanetary nebula.

The thrust of the research project this summer (1998) was to determine whether a nebular analog to the PRW is viable, a so-called *nebular Rossby wave* (NRW), and if so, to explore possible ramifications of this wave to the evolution of the nebula. This work was carried out primarily by S. Davis, J. Cuzzi and me, with significant discussions with P. Cassen. We believe we have established a good case for the NRW and as a result believe we have opened up a new and possibly interesting line of research in regard to the nebular development, in particular with regard to zonal jet formation, a potent accretion mechanism, and possible ties to vortex formation.

The standard model of the protoplanetary nebula consists of a large disk of gas with about 1 % entrained dust gravitationally bound to a large central mass,  $m_c$ , i.e., the protostar. The planet-forming region of the disk extends to roughly 100 A.U. in radius. Disk thickness,  $H$ , is believed to be on the order of 10-100 times less than disk radius. Disk lifetime is on the order of a million years.

Many features of the nebula are direct analogs of those in planetary oceans and atmospheres, so one can expect similar behaviors in several important respects. Firstly, since both are thin, nearly inviscid, barotropic, incompressible, low-Rossby-number fluids, one expects both systems to behave essentially two-dimensionally, i.e., they should approximately conform to the Taylor-Proudman theorem ( $(2\Omega \cdot \nabla)\mathbf{u} = 0$ ). Secondly, to first approximation, both systems should demonstrate geostrophic flow, i.e., flows should move in rough balance between the pressure gradient force and the Coriolis force. Nebular geostrophy has been substantiated numerically by flow visualizations and statistics.

Rossby waves are deviations from pure geostrophic flow. Alternatively, they can be viewed as absolute vorticity conserving waves which arise in systems in which the Coriolis parameter,  $f$ , varies spatially. Geophysically  $f$  varies with latitude ( $f = 2\Omega \sin(\theta)$ ), while in the nebula  $f$  varies with radius ( $f = 2\Omega = 2\sqrt{Gm_c}r^{-3/2}$ ). Since absolute vorticity is nearly conserved for both fluid types, the displacement of a fluid element (a column of fluid, in the present cases) across lines of constant Coriolis parameter results in a change in the element's relative vorticity which advectively restores and overshoots the element across the lines of constant Coriolis

parameter. This periodic advective motion of fluid elements is the Rossby wave. For small radial displacements where one can treat  $\beta$  as effectively constant, one can obtain an approximate dispersion relation for the NRW by linearizing the vorticity conservation equation,

$$\nu = \langle v \rangle k - \frac{\beta k}{(k^2 + l^2)} = \langle v \rangle k - \frac{\sqrt{Gm_c} k}{k^2 + l^2} r^{-5/2} = \langle v \rangle k - \frac{k}{k^2 + l^2} \frac{\Omega}{r} \quad (0.1)$$

Here  $k$  and  $l$  are azimuthal and radial wavenumbers. The azimuthal phase velocity,  $v_\phi = \frac{\nu}{k}$ , relative to the mean azimuthal zonal flow  $\langle v \rangle$  is simply;

$$v_\phi - \langle v \rangle = -\frac{\beta}{k^2 + l^2} = -\frac{\sqrt{Gm_c}}{k^2 + l^2} r^{-5/2} \quad (0.2)$$

Several points are worth noting: a) the dispersion relation for NRW has the same general form as the dispersion relation for the PRW, except for differences in the  $\beta$  term; b) like the PRW, the NRW is dispersive, with the lowest mode number waves having the highest phase velocities; and c) the frequency and phase velocity decrease radially outward in the nebula. In geophysical systems, Rossby waves propagate westwardly with respect to zonal flows, typically with phase velocities of a few m/sec. In the nebular case, taking the central gravitator to be the mass of the Sun, the azimuthal phase velocity for the lowest order mode ( $\lambda \sim 1$  A.U.) at the Earth's radius should be about 300 m/sec. These phase speeds are lower than typical nebular sound speeds.

Given the strong physical similarities between planetary and nebular fluids, it is reasonable to expect that many of the large-scale phenomena involving PRW in planetary fluids could apply to the NRW in the nebula. The most interesting to us is the Rhines inverse energy cascade (Rhines, 1975, 1994) by which broadband Rossby wave turbulence can be organized into large-scale zonal flows as seen on Earth in the form of jet streams and in the form of high speed zonal winds of the Jovian planets' atmospheres. Should analogous zonal jets evolve in the nebula, these could foreseeably influence accretion of planetesimals via enhanced gas drag. Also the velocity shear between jets could possibly provide fertile ground for the formation of vortices.

It is known from both theory and observation that closely-packed two-dimensional fluid motion at high Reynolds number can evolve toward larger scales. This is manifested by the appearance of small wavenumber waves and zonal jets. Zonal jet formation appears to be a robust phenomena, as argued by Vallis and Malthud (1993), and therefore, although the particulars may be different for a spherical geophysical system and the nebular cylindrical one, the general behavior should be similar. It is plausible that the nebula could organize into an analogous series of radially-spaced counterstreaming azimuthally zonal jet pairs. Remarkably, such zonal jets appear to have been discovered by Cabot (1996) in numerical simulations – and under more realistic conditions than are assumed here. Observationally, the signature of jet structure – should future generation infrared or microwave telescopes be able to discern adequately the velocity profile of disks – would

be spatially-banded differential Doppler shifts between opposite sides of the disk. At the Rayleigh limit, to discern a 1 AU wide jet at a distance of 150 ly with 1 mm radiation would require a telescopic baseline of about  $10^4$  m.

Counterstreaming zonal jets may offer an effective means for accreting larger bodies. Consider solid bodies large enough that they are decoupled from the gas flow and execute Keplerian orbits throughout a jet pair. In the inner jet a body experiences a tailwind which should move it via aerodynamic drag to a larger orbital radius, while a body in the outer jet experiences a headwind, forcing it to a smaller orbital radius. Bodies should converge into the narrow region between the jets – the velocity null – where the average gas velocity is zero in the corotating frame. In other words, here the gas and the solid bodies are both in Keplerian orbits. This ‘radial focussing’ mechanism has a number of interesting features. Firstly, drag-induced radial velocities can be large for small and moderately sized bodies (Weidenshilling and Cuzzi, 1993). The direction of the drag force around the velocity nulls is such that even if particles attempt to leave (e.g. by gravitational or collisional scattering), they are quickly returned to the null – that is, the shear velocity profile around a null acts as an attractor. Also, should the jet structure be stable, the velocity nulls would seem to act as a series barrier against drag-generated influx of macroscopic bodies into the protostar. The radial concentration of mass into the nulls makes this mass more susceptible to collisions and perhaps, to further collapse by gravitational instabilities along the azimuthal direction .

Vortices in circumstellar disk models can be found as far back as Laplace and in the cosmogonies of Von Weizsäcker and Alfven. Lately interest has been revived, with notable successes. Barge and Sommeria (1995) argue that: a) long-lived vortices efficiently accumulate solid particles, perhaps acting as nuclei for planetesimals and planets; b) vortices can locally concentrate nebular surface densities by several orders of magnitude; c) vortex mass capture should maximize near the Jovian radius; d) the known mean density differences between the planets might also be tied to the dynamics of vortex capture. Adams and Watkins (1995) show that, in the quasi-geostrophic approximation, the most long-lived, positive mass density vortices naturally generate prograde rotating bodies. This also may contribute to resolution of the celebrated spin problem. Common to these investigations is a call for robust scenarios and mechanisms by which vortices form. The velocity shear between these jets could prove to be fertile ground for the growth and sustenance of vortices in a analogous manner to those in the Jovian planetary atmospheres. Furthermore, in between the jets, in the velocity null, anticyclonic vortices are likely to be stable In contrast, anticyclonic vortices in the alternate velocity nulls are laminated away in the velocity shear. Coincidentally, the location of the anticyclonic velocity nulls coincide with the locations already predicted to be the site of radially focussing by gas drag.

Currently, the case for the NRW appears to be sound, but additional study is necessary to determine the

legitimacy of NRW ties to zonal jets and vortices. To date, S. Davis and I have submitted a poster abstract entitled, "Rossby waves in the protoplanetary nebula" to the Oct. 1998 AAS-DPS meeting in Madison, WI. We are also completing a manuscript on the same subject tentatively to be submitted to Icarus.

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**FINAL REPORT**  
1998 NASA-ASEE-STANFORD SUMMER SECOND YEAR FELLOW

360104

**COMPOSING, ANALYZING AND VALIDATING SOFTWARE MODELS**

31

Frederick T. Sheldon,  
Assistant Professor of Computer Science  
University of Colorado at Colorado Springs

526-91  
415 356

## 1. Introduction

This research has been conducted at the Computational Sciences Division of the Information Sciences Directorate at Ames Research Center (Automated Software Engineering Grp). The principle work this summer has been to review and refine the agenda that were carried forward from last summer.

## 2. Goal

Formal specifications provide good support for designing a functionally correct system, however they are weak at incorporating non-functional performance requirements (like reliability). Techniques which utilize stochastic Petri nets (SPNs) are good for evaluating the performance and reliability for a system, but they may be too abstract and cumbersome from the stand point of specifying and evaluating functional behavior. Therefore, one major objective of this research is to provide an integrated approach to assist the user in specifying both functionality (qualitative: mutual exclusion and synchronization) and performance requirements (quantitative: reliability and execution deadlines). In this way, the merits of a powerful modeling technique for performability analysis (using SPNs) can be combined with a well-defined formal specification language. In doing so, we can come closer to providing a formal approach to designing a functionally correct system that meets reliability and performance goals.

## 3. Motivation

The correctness, safety and robustness of a critical system specification are generally assessed through a combination of rigorous specification capture and inspection; formal modeling and analysis of the specification; and execution and/or simulation of the specification (or possibly a model of such). In a perfect world, verification and validation of a software design specification could be possible before any code was written (or generated). Indeed, in a perfect world we would know that the implementation was correct because we could trust the class libraries, the development tools, verification tools and simulations etc., to provide the confidence needed to know that all aspects (including complexity, logical and timing correctness) of the design were satisfied fully and correctly (i.e., everything was right). Right in the sense that we built it right (its correct with respect to its specification) and it solves the right problem. In our view of the world, we constrain those classic notions first to verifying that at least all of the possibly bad things we could think of can not happen or at least the chances of happening are well bounded. Second, that the performability of the models of what we *plan* (or propose) building are determined to be adequate with respect to function, structure and behavior and the assumptions of the operating environment and potential hazards. Therefore, it is useful to develop and validate methods and tools for the creation of safe and correct software based on the premise that its not a perfect world. Moreover, methods and tools are needed for software model creation/composition and analysis in an open environment including:

- \*Reduce the effort of constructing reliable models
- \*Application level performance and reliability analysis
- \*Improve the tractability of verifying correctness and validating performance
- \*Linking stochastic Petri nets with model checking
- \*Tool supported rigorous methods for reasoning about software and systems

## 4. Accomplishments

The following is a list of tasks that have been accomplished:

- \* Completed implementation of the Petri net reduction rules in CSPN.
- \* Completed implementation of a P-CSP primitive (asynchronous send (i.e., non-blocking send) and the design of the inhibitor arc (deduced from the Petri net construct) construct which was (or will be) integrated into the CSPN tool. We are looking into the problem of generating the inhibitor arc circle heads so that the dot tool will graph a correct representation of a Petri net with an inhibitor arc. Chuck Rodaker demonstrated this work on August 18th
- \* Completed prototyping four tasks (related to Project DUO, see Figure 1). Task 1 reads a CSPL specification of a Stochastic Petri Net (SPN) and an efficient (at this point we have not determined the complexity of searching this data structure) to search data structure; Task 2 generates a reachability graph using post-elimination (of vanishing states / markings) technique from the data structure; Task 3 generates a reachability graph using on-the-fly elimination and; Task 4 populates a Q-matrix (generator matrix) with the stochastic parameters which can then be handed off to the Markov solver. Shane Holloway presented his re-implementation (i.e., from C to C++) of this work on July 14<sup>th</sup> which was not quite running correctly by the time he left.
- \* Some preliminary work has been accomplished in defining a subset of the Promela language into stochastic Petri nets (e.g., comparing Promela to P-CSP and installing SPIN). Chuck Rodacker presented this material on August 18<sup>th</sup>.
- \* Stefan Greiner visited from July 15<sup>th</sup> (he arrived on July 14<sup>th</sup> and we conducted discussions with Shane off site at Stanford) through July 23<sup>rd</sup>. Stefan gave two talks. The first was about Warranty Cost Prediction (using field data, fault trees mapped to Petri nets and subsequently to Markov models). The second talk was open and centered on comparing the power and features of algorithms in the two separate worlds of Model Checkers versus Markov models. A summary of the issues that were discussed in the second was collected by myself and distributed. There were a number of important questions that deserve further investigation and possibly a paper could be generated.
- \* Completed the research paper "Composing, Analyzing and Verifying Software Models to Predict and Assess the Performability of Competing Designs," and submitted it to Annals of Software Engineering.

## 5. Future and Ongoing Work

Ongoing work is to take generate a reachability graph (RG) from a description of the stochastic Petri net (SPN) as follows: CSPL (C-based SPN language) → Extended RG (includes vanishing markings) → RG → Q-matrix which is the starting point for doing Markov solutions. Future (planned enhancements underway) include:

- \* GUI with SPN Editor → CSPL
- \* Translation of Promela-based model into SPNs (using CSPL as a meta-language)
- \* Extending the CSPN language
- \* Implementation of solution methods
- \* Fault-tree analysis

Some ideas that should be explored include linking a discrete event simulation language into the DUO environment and how to relate stochastic results back (mechanically) to the original model as a process of refinement in light of prior runs (sensitivity analysis). Mike Lowry suggested that we look at developing a stochastic model of the error handling mechanisms in the DS1 executive. I am hoping he can get me a (sanitized) copy of the Lisp code. This would be an excellent way to validate our approach.

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3P

The Identification of Complex Organic Molecules in the Interstellar Medium: Using Lasers and Matrix Isolation Spectroscopy to Simulate the Interstellar Environment

Bradley M. Stone

Associate Professor of Chemistry  
San Jose State University

527-90

415357

I. Introduction

a. The Astrochemistry Group

The Astrochemistry Group at NASA Ames Research Center is interested in the identification of large organic molecules in the interstellar medium. Many smaller organic species (e.g. hydrocarbons, alcohols, etc.) have been previously identified by their radiofrequency signature due to molecular rotations. However, this becomes increasingly difficult to observe as the size of the molecule increases. Our group is interested in the identification of the carriers of the Diffuse Interstellar Bands (absorption features observed throughout the visible and near-infrared in the spectra of stars, due to species in the interstellar medium). Polycyclic Aromatic Hydrocarbons (PAHs) and related molecules are thought to be good candidates for these carriers<sup>1</sup>. Laboratory experiments are performed at Ames to simulate the interstellar environment, and to compare spectra obtained from molecules in the laboratory to those derived astronomically. We are also interested in PAHs with respect to their possible connection to the UIR (Unidentified InfraRed) and ERE (Extended Red Emission) bands - emission features found to emanate from particular regions of our galaxy (e.g. Orion nebula, Red Rectangle, etc.)

b. Matrix Isolation Spectroscopy

An old, "tried and proven spectroscopic technique, matrix isolation spectroscopy creates molecular conditions ideal for performing laboratory astrophysics, for the following reasons:

i. Molecules can be examined spectroscopically under near-isolated conditions. The molecule of interest is trapped in a cage of inert gas atoms (e.g. argon), at cryogenic temperatures, to minimize intermolecular interactions. Molecular species in the interstellar medium exist at minuscule number densities and are therefore truly isolated from one another. Interactions or "perturbations" between a molecule and the surrounding environment are typically well-known and understood from decades of experiments of this nature.

ii. Temperatures approximate those typically experienced by molecules in the interstellar medium (~4 - 12 K).

iii. Matrix isolation provides a means to trap and "bottle up" ionized species (e.g. cations of PAH molecules). Molecular ions may be kept in this fashion for days and even weeks, thereby providing a means to conveniently study them spectroscopically.

c. The Perylene Molecule

Studies this summer have centered around investigating the laser fluorescence spectra of the perylene cation ( $C_{26}H_{12}^+$ ) trapped in a cryogenic (argon) matrix. Previous studies by Joblin et al.<sup>2</sup> demonstrated that the fluorescence spectrum of the perylene cation could be observed by excitation with an incoherent light source. Our present study extends this work by using a laser system as the excitation source.

II. Experimental

A detailed description of the ultra-high vacuum system, cryostat and conditions for forming the matrix is given elsewhere<sup>3</sup>. Detection is achieved by a Oriel CCD/0.3 m monochromator combination, using Oriel's Instaspec software, as is described by Chillier et al.<sup>4</sup> A summary of the capabilities of the laser system is given below, and are also described in detail by Chillier et al.<sup>5</sup> A diagram of the experimental setup is shown in Fig. 1.

Laser System for Molecular Excitation and Observation of Fluorescence:

- Centered around an Alexandrite Laser - a tunable, solid-state laser with a wavelength range of 715 - 800 nm.
- Second Harmonic Generation (SHG,  $2\omega$ ) by frequency doubling of fundamental in a birefringent crystal.
- Sum-Frequency Upconversion (THG,  $3\omega$ ) - frequency mixing of fundamental and second harmonic to generate the third harmonic, in a second birefringent crystal.
- Shifting of the frequency by Stimulated Raman Scattering, a non-linear, coherent process whereby any of the harmonics above can be shifted by an integral multiple of the vibrational frequency of the diatomic molecule used to scatter the light.

III. Results

- The laser system was completed this summer. We now have the capability of exciting molecules from ~ 230 nm. to 2.5  $\mu$ .
- First laser fluorescence spectra of a Polycyclic Aromatic Hydrocarbon (PAH) ion ever observed. Laser fluorescence spectra of perylene cation obtained, after excitation of the  $D_5$  and  $D_3$  electronic states. Emission is observed from the  $D_1$

electronic state of the cation. The absorption spectrum of perylene cation is shown in Figure 2, indicating the positions of laser excitation. Fluorescence from the D<sub>1</sub> state, following excitation to the D<sub>3</sub> state, is shown in Figure 3. Fluorescence from the D<sub>1</sub> state, following excitation to the D<sub>5</sub> state, is shown in Figure 4.

- First observation of an ultraviolet transition in a PAH cation. The high-lying electronic state responsible for this transition is in the same wavelength region as in the neutral, making it difficult to observe. However, fluorescence from the D<sub>1</sub> state of the cation in the infrared, which is unique to the ion, provides an ideal probe for the high-lying ion state via excitation spectroscopy. The excitation spectrum of the ion, achieved by scanning the laser wavelength in the ultraviolet while monitoring the fluorescence of the ion in the infrared, is shown in Figure 5.
- Laser fluorescence spectra were also observed from ionized perylene clusters (as a follow-up to earlier work by C. Joblin). Clusters of PAH molecules may help to explain the so-called Extended Red Emission (ERE) seen in some regions of the galaxy (i.e. from some nebulae).
- Luminescence spectra were also recorded during the process of warming up the matrices. Emission appears to occur from cation-electron recombination. Surjit Kaur (M.S. Chemistry student from SJSU) is currently working on the investigating the nature of the emitting species in these spectra.

#### IV. Future Directions

- Understand more completely the electronic spectroscopy of perylene, and to map out the excited electronic states of both the neutral and the ion.
- Look at laser fluorescence from some other PAHs (including completely aromatic systems), e.g. pyrene.
- Investigate more completely the fluorescence from perylene clusters (and other PAH clusters), to try to make the possible connection with emission features such as the ERE in the galaxy.
- Attempt to understand the physics of the electron-cation recombination process upon the warming up of the matrix, and the nature of the emitting species giving rise to luminescence of the matrix.
- Extend the capabilities of the laser system to do automated excitation scans.

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#### VI. Acknowledgments

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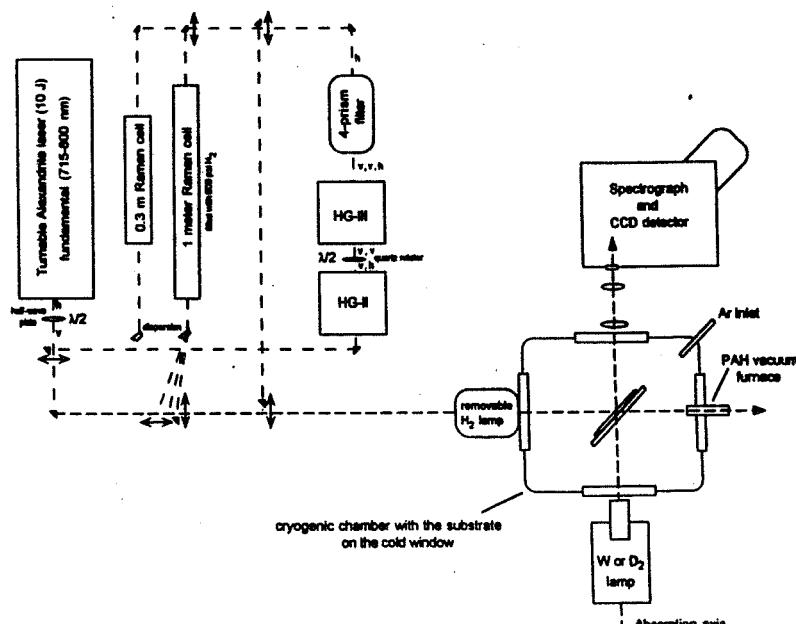


Figure 1. Diagram of the laser fluorescence setup.

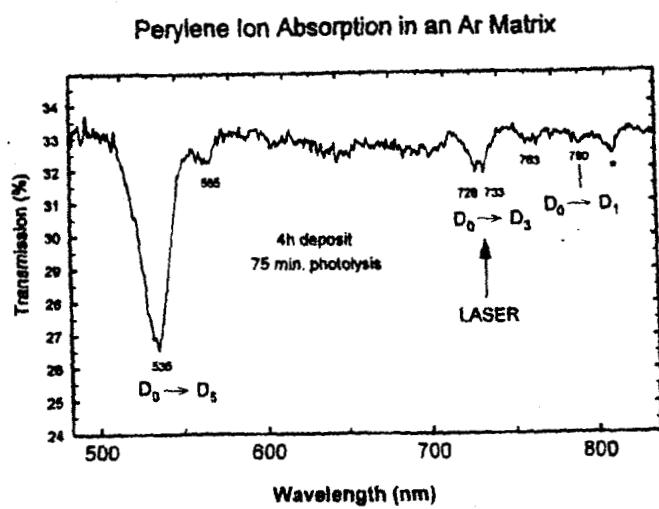


Figure 2. Absorption spectrum of the perylene cation.

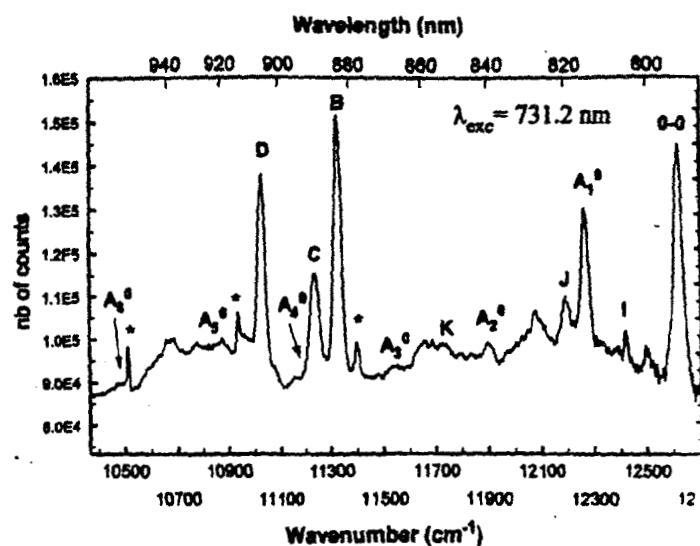


Figure 3. Fluorescence from perylene cation following laser excitation of the D<sub>3</sub> electronic state.

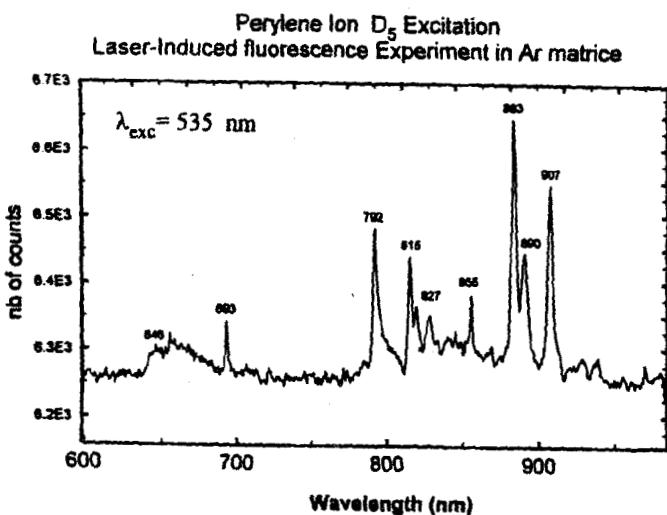


Figure 4. Fluorescence from perylene cation following laser excitation of the D<sub>5</sub> electronic state.

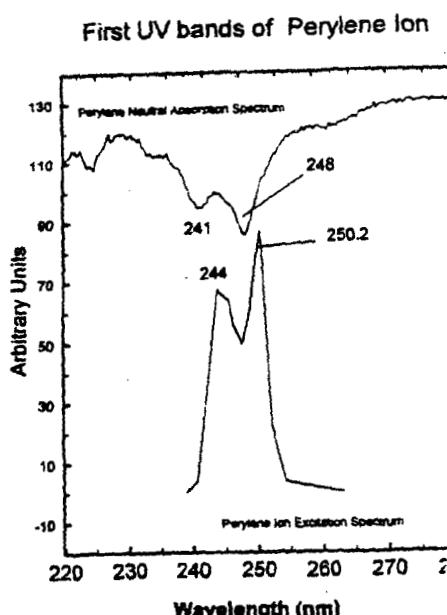


Figure 5. Excitation spectrum of the ultraviolet of the perylene cation.

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1998 NASA-ASEE-Stanford Summer Fellowship  
Final Report

Ecological Support of Larval Fish During Multigenerational Studies on Space Station

Frieda B. Taub  
Professor, School of Fisheries  
University of Washington

360129

31

### 1. Introduction

Live, microscopic food is required by larval Zebrafish, *Danio rerio*, which are candidates for the Aquatic Habitat of the Space Station Biological Research Project (SSBRP). Zebrafish have proven to be convenient research animals, and their embryology and genetics are extensively documented. Their ability to mature at 3 months of age, and the transparent eggs which hatches in 2 days, are attractive attributes for space research. Among the goals of the SSBRP Aquatic Habitat is the ability to study three generations, with the objective of maintaining adults, their offspring, and the maintaining of these offspring through maturity and spawning. For Zebrafish, it is anticipated that sexually mature fish (P1) would be delivered to Space Station and spawned in space. The challenge would be it to provide appropriate microscopic foods for the offspring (F1), and 3 months later for the next generation (F2); if these were raised to maturity and bred, live foods would be required at approximately 6 months. In laboratories where Zebrafish are traditionally reared, the larval foods are the protozoan *Paramecium micromultinucleatum* and later brine shrimp *Artemia nauplii*. Under normal laboratory conditions, the rearing of these foods are relatively easy, although time consuming because of the food organisms must be separated from their rearing medium which is discarded. A freshwater food chain that would ensure healthy on-orbit research animals is needed. The food chain should (a) be reared in conditions that are compatible with the larval fish (water chemistry, pH, temperature and light), (b) assist in maintaining water quality (by removing ammonia, nitrate, phosphate, carbon dioxide, and bacteria) and (c) be convenient for the space crew (minimize handling and waste production).

The freshwater food chain is simple in concept (algae-> grazer(s)->fish), but difficult in execution, especially if a limited number of food organisms are to be used. In most freshwaters, a variety of algae, protozoa, and bacteria are available, and the nutritional limitations of one alga can be supplied by other organisms. The nutrition and feeding of marine fish larvae is an active field of research. However, most of these studies are conducted at 10-15 C and in saltwater, so the findings must be adapted to warm, freshwater environment of Zebrafish.

The selection of the algae is critical, because they will determine the nutritional value of the grazers that will be eaten by the larval fish. Currently, emphasis has been placed on the essential fatty acids that marine fishes have been shown to require, and that are present only in some algae. It has long been known that some algae are consistently "good" food while others are of variable quality, and tend to be "poor" foods. Chemical analyses suggest that the presence of polyunsaturated fatty acids (PUFA) indicates the quality of feed, especially for zooplankton and larval fishes (Ahlgren et al. 1990, Ahlgren et al. 1992). The highest concentrations of PUFA are in flagellates (*Rhodomonas* and *Cryptomonas*), which grow at 15 C. Of the organisms that would grow at 25 C, M. Brett (University of Washington, Civil Engineering; personal communication) suggested the green alga *Scenedesmus acutus*, which has some PUFA precursors. With these studies in mind, the criteria for a Zebrafish food chain were established.

## 2. Criteria:

- Growth compatible with fish rearing conditions (28 C, fish water, 14 /10 hr light/dark).
- Easily cultured, (routinely used as toxicity test organisms or aquaculture feeds).
- Stored stages such as cysts or resting eggs that remain viable at least 6 months .
- (Algae--see below for candidates) , high nutritional value for grazers , take up ammonia, nitrate, carbon dioxide, and release oxygen (during 14 hour light phase).in the light..
- Small micrograzer (<200  $\mu$ ), suitable for initial feeding of Zebrafish larvae..
- Medium micrograzer (< 800  $\mu$ ), suitable as a secondary food until the Zebrafish larvae are mature enough to feed on dried fish food.

Among the candidates are:

### Algae:

*Nannochloropsis oculata*, is the traditional food for marine rotifer *Brachionus plicatilis*, and the alga is reported to grow in freshwater media (now being tested). It is supplied on "Micro Algae Disks" which the supplier (Florida Aqua Farms) claims will remain alive for 6+ months. Dense paste is available in frozen form. Non-motile.

*Scenedesmus acutus*, reported to be highly nutritious for *Daphnia*, and presumably for *Ceriodaphnia* and rotifers. No storage form is marketed, but the "Micro Algae Disks"™ technique might be suitable. Non-motile.

*Selenastrum capricornutum*, the traditional food for *Ceriodaphnia*; it is sold in concentrated, refrigerated solution ( $10^7$  cells/ml by Aquatic Research Organisms) and retains its feeding value for several months. Non-motile.

*Euglena gracilis* ( a photosynthetic protozoan or alga), high nutritional value for invertebrates (and potentially fish larvae), requires B12, as do rotifers, and probably fish. Good fatty acid composition. Removes ammonia and several organic compounds, takes up carbon dioxide and releases oxygen. Frozen cultures are available from the American Type Culture Collection, or in liquid culture from Carolina Biological Supply Company. Motile, by flagella.

### Micrograzers:

Rotifer, *Brachionus calyciflorus*, replacement for *Paramecium*, food for first feeding larvae, feeds on algae and bacteria; requires good fatty acids in diet to be good fish food. Resting cysts are marketed by several companies, including Aquatic Research Organisms and Aquatic Research Organisms. The cysts are reported to be very easy to hatch and rear in densities of hundreds per ml; they are used in freshwater toxicity testing. Motile, by cilia.

*Ceriodaphnia dubia*, replacement for Artemia, feeds on algae and bacteria, eaten by larval Zebrafish as a second food. Resting eggs (ephippia) are expected to be marketed by the end of 1998. Live cultures are available from a large number of sources because they are used in toxicity testing. Motile, swimming appendages.

Lee (1997) successfully used mixtures of algae, rotifers, and *Artemia* to rear a variety of marine fish larvae. Because *Ceriodaphnia* may compete with or physically damage rotifers, it is suggested that they be added when the fish are old enough to feed on them. It remains to be seen if feed organisms will need to be added, or if they will be supplied in excess, and that modest levels of reproduction will compensate for fish predation.

### **3. Experimental Work Performed:**

All of the organisms have been obtained, and are being successfully cultured at Ames. The *Scenedesmus* culture was contributed by Dr. Michael Brett, Civil Engineering, University of Washington. Ceridaphnia and live rotifers were contributed by Linda Deanovic of University of California, Davis.

*Scenesdesmus* grew well at 28 C, in a variety of freshwater algal media (T82, T82+Soil Extract, and Alga-Gro<sup>TM</sup>). Alga-Gro<sup>TM</sup> (Carolina Biological) was selected as the most suitable medium because it contains vitamins B<sub>12</sub>, Thiamin and Biotin; these are not needed by the algae, but may be necessary for the grazers, and may improve their nutritional value to the fish larvae. Its cultures support dense cultures of these cultures the rotifer, *Brachionus calyciflorus*.

*Nannochloropis* has been activated from a "Micro Algae Disk" <sup>TM</sup>., and is being tested for growth in freshwater medium. After a lag of several days, it has increased 10 fold within a week's time. It is a suitable diet for *Brachionus calyciflorus*

*Euglena gracilis* has shown the ability to prolong survival of Zebrafish larvae a few days longer than those fed other algae, or un-fed. *Euglena* has also provided rapid reproduction of the rotifers, *Brachionus calyciflorus*.

Rotifers grown on live *Scenedesmus*, *Euglena*, and *Nannochloropis*, developed dense cultures. The frozen algal paste of *Nannochloropsis* and/or Roti-Rich were not successful in maintaining rotifer cultures under the conditions tested. The "hatching" of rotifer cysts from Aquatic Research Organisms required two to three days to hatch.

*Ceriodaphnia dubia* cultures have done very well, fed on either Roti-Rich or *Selenastrum*+YTC. Dense cultures are available for feeding studies.

Preliminary feeding studies on 30 Zebrafish larvae have commenced, using the rotifers that grew on live algae. The larval fishes appear to be eating the rotifers, but it is too early to assess growth. A larger, more controlled feeding study will be initiated and survival and growth will be measured at 10 days, for comparison with earlier studies on artificial diets.

### **4. Potential Future Work.**

- a. Evaluate *Nannochloropsis* growth rate in freshwater medium.
- b. Test if either *Nannochloropsis* or *Ankistrodesmus* would be adequate to remove nitrate.
- c.. Test if a single or pair of algae would be an nutritionally adequate.
- d. Test algae, rotifers, and *Ceriodaphnia* to determine if survival and growth of the fish larvae is adequate until the fish can eat dried fish food.

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**Textural and Carbon Isotopic Analyses of Modern Carbonate Microbialites:  
Possible Ancient and Martian Analogs**

Joel B. Thompson  
Assistant Professor  
Eckerd College

529-46

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3P.

**Introduction**

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Many modern and ancient carbonate deposits around the world have been recognized as microbial buildups or microbialites. Ancient microbialite structures have been divided into two basic categories based on their internal fabric or texture. They include stromatolites which have a predominantly laminated internal fabric and thrombolites which have an open-porous clotted fabric, that lacks laminae. The origin of these two basic microbial fabrics is still being debated in the literature (1). Understanding the origin and the various microorganisms involved in forming these modern fabrics is the key to the interpretation of similar fabrics in ancient and possibly Martian rocks.

Therefore, detailed studies are needed on the microbiological makeup and origin of the fabrics in modern microbialites. Such studies may serve as analogs for ancient and Martian microbialites in the future. The purpose of this study is to examine the textures and carbon isotopic signatures of the following modern microbialites from the Bahamas: 1) a modern subtidal microbialite from Iguana Cay, Bahamas and 2) a modern microbial mat (stromatolite) from a hypersaline pond on Lee Stocking Island, Bahamas.

**Methods**

The textures or fabrics of these microbialites from the Bahamas are being investigated by light microscopy, scanning electron microscopy, and transmission electron microscopy. These microscopic methods will also allow us to investigate the various microorganisms contained within the modern microbialites and their resulting fabrics. Samples for SEM were fixed in glutaraldehyde, put through an alcohol dehydration series, critical point dried, and gold coated. TEM samples were fixed in glutaraldehyde, dehydrated in alcohol and embedded in resin for thin-sectioning on an ultramicrotome.

We are also investigating the carbon isotopic signatures of the microbialites as possible geochemical indicators of their microbial origin. Thompson and Ferris (2) and Thompson et al. (3) have shown that modern lacustrine microbialites formed predominantly by *Synechococcus* (a coccoid cyanobacterium) are significantly enriched in  $^{13}\text{C}$  due to the uptake of  $^{12}\text{C}$  for organic biosynthesis. Carbonate samples for carbon isotopic composition were treated with chlorox to remove all organic matter, rinsed, and dried before being vacuum-sealed in Y-tubes with pure phosphoric acid. The reactions with the acid were carried out overnight in an oven at 50 °C and the  $\text{CO}_2$  will be analyzed on a Nuclide 6-60 RMS mass spectrometer modified for small-sample analysis (4). The  $\text{CO}_2$  was purified from water and other nonvolatile constituents (e.g. salts) by passing it through a methanol dry ice bath and a variable-temperature cold trap (5), holding it at -125 °C, and then

trapping the CO<sub>2</sub> in a -196 °C liquid nitrogen trap. The volume of CO<sub>2</sub> was measured with a mercury manometer and flame-sealed in 6-mm Pyrex tube for isotopic analysis. For the overall procedure, the 95% C.L.s were  $\pm$  0.2 per mil. All isotopic results are reported as per mil values (relative to PDB standard) as follows:  $d^{13}\text{C} = [(\bar{R}_{\text{sample}}/\bar{R}_{\text{std}}) - 1] \times 1000$ , where  $R = ^{13}\text{C}/^{12}\text{C}$  and  $\bar{R}_{\text{std}} = 0.0112372$ .

## Preliminary Results

Microscopic examination of the small (25 cm high) subtidal microbialite from Iguana Cay, Bahamas revealed that it contained three distinctive fabrics. They include a laminated stromatolitic fabric at the base (i.e., the lower 10 cm), a calcareous algae fabric in the middle (~ 5 cm thick) and a thrombolitic fabric at the top (the upper 10 cm). All three fabrics were microscopically inspected and analyzed for their carbon isotopic signatures by drilling small subsamples and processing them for carbonate isotopic analyses as noted above. In addition some molluscan shell material was subsampled from within the Iguana Cay microbialite. This molluscan material should be in equilibrium with the surrounding seawater at the time of shell formation. Therefore, they may indicate what the equilibrium water values should have been at the time of formation of the microbialite. In total 38 carbon isotopic samples were processed. All isotopic values will be obtained shortly as they are currently waiting to be run on the Nuclide 6-60 RMS mass spectrometer.

Scanning electron microscopy of the recent stromatolitic mat from Lee Stocking Island, Bahamas revealed four distinctive microbial population layers. First an upper diatom and filamentous cyanobacterial layer dominated by *Oscillatoria*. Second a thick *Microcoleus* dominated layer. Third a purple sulfur bacteria layer. Fourth an anaerobic layer containing green sulfur bacteria and sulfate reducing bacteria. SEM revealed that only the purple sulfur bacteria layer showed any signs of recent calcification. The individual purple sulfur bacteria within their microcolonies were completely surrounded and encased in very fine grain micrite. These observations revealed that the micrite precipitated in situ and was not trapped and bound as suggested for many ancient stromatolites. This layered structure was repetitive with depth within the mat. The carbonate layer was also repeated at the same location with the repeat. However the carbonate crystals became larger with depth within the mat. The crystals were identified as high mg-calcite via energy dispersive x-ray analysis on the SEM.

## Conclusion and Future Direction

No significant conclusions can be made at this time as we still await the 38 carbon isotopic values. Much more detailed work remains to be done in this area. We plan to continue this work throughout the next academic year and into next summer given that this program is still available for the second year fellows.

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1998 NASA-ASEE-Stanford Summer Fellowship Final Report

Tom Tucker, Technical Writing Instructor, Isothermal Community College

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31.

**Harnessing the Brute:  
The Development of Propulsion Controlled Aircraft at NASA Dryden**

360132

## 1 Introduction

PCA, Performance Control Aircraft, is a backup flight control system for use when an airplane has lost all its hydraulics and normal flight controls. PCA is an autopilot system which modulates the thrust of the engines to provide lateral and longitudinal direction and enables the pilots to land the airplane. NASA Dryden has developed this technology in flight, ground simulator, and analytic studies which started as early as 1989. NASA Dryden has combined efforts with NASA Ames, McDonnell Aerospace St.Louis, Douglass Aircraft Long Beach, Honeywell, Pratt & Whitney, the US Air Force, and the US Navy to develop PCA to the point where it is feasible to bring a commercial airliner not just to a survivable crash landing but to a normal landing.

The purpose of my project was to develop a history of an invention which evolved by group problem-solving. My focus was not on validations arrived at -- these are already documented in technical reports -- but on the inventive process. I have previously published work about individual inventors and their processes, one of these studies concerning Philo Farnsworth's Image Dissector, the crucial invention for all-electronic television [1]. The Image Dissector history concerns the classic lone inventor scenario. But PCA is the history of often reconfigured teams developing an invention in our modern environment governed by complex commercial and regulatory units, a story of, as one engineer put it, "how you push a good idea through the system."

## 2 History of Inspiration

At 30,000 feet altitude flying to St. Louis on a business trip, Bill Burcham, then Chief Propulsion Engineer at NASA Dryden, first began to think about PCA. The idea started as a sketch on the back of a TWA cocktail napkin. It was September, 1989, and he had just laid aside a copy of an industry magazine describing a commercial airline disaster.

On July 19, 1989, United Flight 232 had experienced disaster during a routine cruise over Iowa farmlands. The rear engine of the DC-10 had blown out, destroying the hydraulic system. The hydraulics operate all the controls which a pilot uses to control flight. The airplane had three hydraulic systems, two of them independent backups, but the shrapnel from the explosion took out all three. Suddenly, the control stick was dead in the pilot's hand.

The crew made the discovery that by nudging the throttles to the two remaining engines, they could herd the airplane across the skies. Flight controllers directed the airplane to the Sioux Gateway Airport at Sioux City, where emergency preparations had already begun. At 1600

hours, the airliner made a partially successful landing on Runway 22, cartwheeled during touchdown, yet 184 of the 296 on board survived the crash and ensuing fire.

What more could I have done to help the pilots, wondered Burcham. He asked, could the raw power of the engine bring a crippled airplane down to a safe landing? He thought about the whole new generation of airplanes evolving with automated flight control computers and with computers that digitally ran the engines. Could the brute force of engine thrust be harnessed to control the airplane? Could the airplane's digital software operate the throttles with enough finesse to bring the airplane safely down? [2]

### 3 Concept

To think in terms of how to control an airplane but ignore all flight control surfaces was to return back to the century before the Wright Brothers -- even Orville and Wilbur from the beginning understood that control surfaces harnessed the power of flight. When all control surfaces are lost, there occur certain aerodynamic movements no pilot ever wants unleashed. The two most basic of these are the dutch roll oscillation and the phugoid oscillation.

All of us have experienced phugoids in airflight. They probably make an appearance as no more than slight nibbles in a smooth passage, arising so gradually that normally the pilot touches the stick and kills the oscillation without thinking about it. As long as control surfaces work, the phugoid remains a sleeping monster.

The phugoid is a pitching motion in which kinetic and potential energy (speed and altitude) are traded. The oscillation typically lasts about 60 seconds. As the airplane's nose pitches to the highest point, speed slows. As the nose drops back toward the middle of the cycle, speed increases. Then as the nose pitches down, speed slows. The experience resembles a sort of eerie slow motion roller-coaster ride. Its effect on landings can be fatal.

The dutch roll oscillation has more to do with the lateral axis, and resembles a drunk's walk where the inebriate pauses with every step, tilts on one foot, and lurches in the other direction. The oscillation combines several factors including yaw, roll, dihedral effect, lift, and drag. During the complex mode, the airplane's nose rotates in a 3° lateral mode. Unfortunately, a 1° latitude exists for safe runway touchdowns.

To control these oscillations, the researchers started with manual control. The big lethargic engines took what seemed an eternity to respond. It was wait-and-see flying, a sort of dismaying process of anticipation. The pilot commanded, the pilot waited. To a nonpilot, the comparison would be driving and having to turn the steering wheel ten seconds in advance of any movement needed. A phugoid lasts about 60 seconds and the thrust input to damp it must be given more than 20 seconds before any perceptible cue to do so. Unfortunately in disaster, "Pilots will revert to natural instincts and natural flying instincts will kill you" [3].

The researchers' insight, which dated back to the sketch on the napkin, was that while a pilot would find it impossible to stop a phugoid with only 50-50 odds of even nudging the thrust in

the right half of the oscillation, if a computer could help, if it could 40 times per second receive responses from motion sensors and react to each with a tiny correcting nearly imperceptible nudge of the throttle, the airplane could be controlled.

#### **4 History of Development**

The idea of PCA was big. It was big in unexpected ways and so robust it kicked in sometimes more strongly than the engineers had ever predicted. Burcham was the first impetus behind the project, but PCA was much bigger than any one individual, and teams would form and reform, members dropping in and out, as their assignments required. At a center known for supersonics, this subsonic idea lumbered along with the speed of a transport. It survived, moving through an institution, through units and sub-units, a bit of a stealth project because it had no budget to be shot down, moving through "mature technology," moving through an engineer's off-time on Saturday afternoon, through carpool debates, reviews, and reconfigurations with other units and experts which would help it survive. My project concerns the teams and their members, Gordon Fullerton, the ex-astronaut who became project pilot; the other pilots, Dana Purifoy, John Miller, Ralph Luczak, and Walt Smith; Ken Szalei, NASA Dryden Director, who offered remote but crucial support; important control law work from Trindel Maine, John Burken, Joe Conley, Glen Gilyard, and Ed Wells; Honeywell's Jeff Kahler, the wizard who put PCA in the FCC; the pivotal project management of Drew Pappas; and important management from Jim Stewart, Joel Sitz, Bob Baron, Jim Urnes, and Russ Barber. Through their efforts, a series of historic flights have demonstrated the concept in actual flight landings on the F-15 and on the MD-11. Currently tests continue with the C-17 and B-747 to make this technology applicable to the realities of commercial airlift.

#### **5 Conclusions**

The success of PCA despite widespread skepticism and often zero funding suggests: **1.** A small team with highly skilled individuals may be more effective than putting larger groups with a lower median skill level on a project. **2.** Although budget is key, in certain stages it is not the most important key. **3.** A principle investigator who shares opportunities as broadly as possible enables the project to benefit often unexpectedly. **4.** It may help to leverage upward by reconfiguring with other units, centers, and institutions. There is an art to "surfing" an idea through the industry environment.

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Final Report  
1998 NASA-ASEE Stanford Summer Faculty Fellowship

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**"Making the Learning of Mathematics More Meaningful"**

*31*

**Dr. Robin A. Ward  
Assistant Professor, Mathematics Department  
California Polytechnic State University, San Luis Obispo**

**Background:**

In the early 1980's, the National Commission on Excellence in Education responded to the call for reform in the teaching and learning of mathematics. In particular, the Commission developed a document addressing the consensus that all students need to learn more, and often different, mathematics and that instruction in mathematics must be significantly revised. In a response to these calls for mathematics education reform, the National Council of Teachers of Mathematics (NCTM) developed its *Curriculum and Evaluation Standards* (1989) with a two-fold purpose:

- 1) to create a coherent vision of what it means to be mathematically literate in a world that relies on calculators and computers, and
- 2) to create a set of standards to guide the revisions of school mathematics curriculum (p. 1).

Recognizing the crucial need to better educate teachers and students, NASA has also stepped into the mathematics and science education forefront and has as one of its national

priorities to "involve the educational community in our endeavors to inspire America's students, create learning opportunities, and enlighten inquisitive minds" (NASA, 1998). The Public Affairs Office located at the NASA Dryden Research Center is heavily involved in educating and sharing with teachers and students the sundry research projects with which NASA is involved.

## **Project Highlights:**

In an attempt to address NASA's education priority, several web-based activities were developed which address various topics and concepts taught in the K - 12 mathematics classroom, all couched within the context of a current or past NASA research project. The activities were written in a lesson plan format and are ready for use by the teacher. Each activity begins by informing the teacher of the grade level suitable for the activity and what mathematical topics are covered. Next, a rationale is provided which informs the teacher of how the activity addresses various strands of the NCTM *Curriculum and Evaluation Standards* (1989). Some relevant background information about the activity is given next, describing how the activity relates to various NASA projects and endeavors. Then, materials necessary for the activity are listed, followed by a detailed description of how to implement the activity. At the end of each activity, enrichment activities are provided to further student understanding.

Some of the activities developed include the following:

- Using the X-33 and X-38 spacecrafts, both of which are scaled models, student discover the relationship between area and volume and how area and volume increase in magnitude when the dimensions of the shape are doubled.

- Using actual data from the ERAST Pathfinder aircraft, students gain practice with graph construction and interpretation by plotting temperature, wind speed, altitude, and battery state of charge data.
- Using the AD-1 aircraft as a model, which has a pivoting wing, students engage in estimating and measuring angles and learning how to construct adjacent, complementary, and supplementary angles.

It is hoped that these activities will serve as a rich source for teachers who want to make the learning of mathematics more meaningful, realistic, engaging, and fun for students.

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**Department of AERONAUTICS and ASTRONAUTICS  
STANFORD UNIVERSITY**

**ADMINISTRATIVE &  
SUMMARY TECHNICAL REPORTS**

**NASA Ames Research Center  
Grant No. NGT 2-52212**

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**1998 NASA-ASEE-STANFORD  
SUMMER FACULTY FELLOWSHIP PROGRAM**

Ames Research Center  
Dryden Flight Research Center  
Stanford University

October 1998

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**ADMINISTRATIVE  
REPORT**

**1998 NASA-ASEE-STANFORD  
SUMMER FACULTY FELLOWSHIP PROGRAM**

Ames Research Center  
Dryden Flight Research Center  
Stanford University

October 1998

# **NASA-ASEE Summer Faculty Fellowship Program**

**NASA AMES RESEARCH CENTER  
NASA DRYDEN FLIGHT RESEARCH CENTER  
STANFORD UNIVERSITY**

## **1998 Administrative Report**

### **1. INTRODUCTION**

This report presents the essential features and highlights of the 1998 Summer Faculty Fellowship Program at Ames Research Center and Dryden Flight Research Center in a comprehensive and concise form. Summary reports describing the fellows' technical accomplishments are enclosed in the attached technical report. The proposal for the 1999 NASA-ASEE-Stanford Summer Faculty Fellowship Program is being submitted under separate cover.

Of the 31 participating fellows, 27 were at Ames and 4 were at Dryden. The Program's central feature is the active participation by each fellow in one of the key technical activities currently under way at either the NASA Ames Research Center or the NASA Dryden Flight Research Center. The research topic is carefully chosen in advance to satisfy the criteria of (1) importance to NASA, (2) high technical level, and (3) a good match to the interests, ability, and experience of the fellow, with the implied possibility of NASA-supported follow-on work at the fellow's home institution.

Other features of the Summer Faculty Fellowship Program include participation by the fellows in workshops and seminars at Stanford, the Ames Research Center, and other off-site locations. These enrichment programs take place either directly or remotely, via the Stanford Center for Professional Development, and also involve specific interactions between fellows and Stanford faculty on technical and other academic subjects.

A few, brief remarks are in order to summarize the fellows' opinions of the summer program. It is noteworthy that 90% of the fellows gave the NASA-Ames/Dryden-Stanford program an "excellent" rating and the remaining 10%, "good." Also, 100% would recommend the program to their colleagues as an effective means of furthering their professional development as teachers and researchers. Last, but not least, 87% of the fellows stated that a continuing research relationship with their NASA colleagues' organization probably would be maintained. Therefore, the NASA-ASEE-Ames/Dryden-Stanford Program has met its goals very well and every effort will be made to continue to do so in the future.

Principal Administrative Personnel for the 1998 Program were:

Consulting Professor Michael Tauber, Stanford Co-Director

Ms. Meredith Moore, NASA-Ames Co-Director

Mr. Don Black, NASA-Dryden Flight Research Center Administrator

Ms. Marilyn Jackson, NASA-Ames Administrator

Ms. Melinda Francis Gratteau, Stanford University Administrator

## **2. SELECTED STATISTICAL INFORMATION**

### **Applicants**

Number of applications (for first year fellowships)  
received by February 1, 1996:

1st Choice	41
2nd Choice	14

### **Participants**

Total Participants	31
First Year Fellows	15
Second Year Fellows	16
Male	24
Female	7
Minority Males	6
Minority Females	0
H.B.C.U.	0
Average Age (at end of program)	44.0

### **Degree Distribution**

Ph.D.	29
Master's	2

### **Academic Rank**

Professor	7
Associate Professor	10
Assistant Professor	12
Instructor/Research Faculty	2

### **Geographic Distribution**

States Represented	16
Universities Represented	24

### **3. HIGHLIGHTS OF THE 1998 PROGRAM**

#### **TOPICS RESEARCHED AND REPORTED BY THE FELLOWS**

<b><u>Faculty Fellow &amp; (NASA Colleague/Division)</u></b>	<b><u>University Affiliation</u></b>	<b><u>Title of Research Project</u></b>
Assoc. Prof. Amanie Abdelmessih (1) (Tom Horn/RS)	Dept. of Mechanical Engr. Saint Martin's College	"Experimental Measurements of Temperature and Heat Flux in a High Temperature Black Body Cavity"
Assoc. Prof. Cesar Compadre (1) (Muriel Ross/SL)	Dept. of Biopharmaceutical Sciences, University of Arkansas for Medical Sciences	"Virtual Reality Simulation of the Effects of Microgravity in Gastrointestinal Physiology"
Assoc. Prof. Jane Friedman (2) (Michael Lowery/IC)	Dept. of Math. & Comp. Sci. University of San Diego	"Educational Applications on the World Wide Web: An Example Using Amphion"
Professor Oswaldo Garcia (1) (R. Steve Hipskind/SGG)	Dept. of Meterology San Francisco State Univ.	"The Detection of Polar Stratospheric Clouds Using AVHRR Imagery"
Assoc. Prof. Joel Henry (2) (Ann Patterson-Hine /IC)	Dept. of Comp. & Info. Sci. East Tennessee State Univ.	"Testing and Troubleshooting Embedded Real-Time Software"
Asst. Prof. Paul Herrick (2) (Mike Arebalo/OE)	Dept. of Aviation Tech. Univ. of Alaska at Anchorage	"F18 Life Support - APECS and EDOX Cockpit Integration"
Professor Stanley Herwitz (2) (Robert Slye/SG)	Grad. Sch. of Geography Clark University	"High Resolution Airborne Digital Imagery for Precision Agriculture"
Assoc. Prof. Phil Kesten (2) (Yvonne Pendleton & Dale Cruikshak/SST)	Dept. of Physics Santa Clara University	"Photometric Study of Uranian Satellites"
Asst. Prof. Gene Korienek (1) (Robert Welch/SL)	Dept. of Exercise & Sports Physiology Oregon State University	"The Mars Gravity Simulation Project"
Professor Samaan Ladkany (2) (William Borucki & Robert Strawn/AAR)	Dept. of Civil Engineering Univ. of Nevada, Las Vegas	"Proposed Wind Turbine Aeroelasticity Studies Using Helicopter Systems Analysis"
Asst. Prof. Michael Lambert (1) (Louis Salerno & Susan White/STM)	Dept. of Mechanical and Aerospace Engineering San Jose State University	"Measuring Thermal Conductivity and Moisture Absorption of Cryo-Insulation Materials"
Asst. Prof. Michael Liang (2) (Sara Arnaud /SLR)	Sch. of HEPR - Kinesiology Bowling Green State Univ.	"High Salt Diets, Bone Strength and Mineral Content of Mature Femur After Skeletal Unloading"
Assoc. Prof. Mary Sue Lowery (2) (Nancy Daunton/SL)	Dept. of Biology University of San Diego	"Investigations of the Effects of Altered Vestibular System Function on Hindlimb Anti-gravity Muscles"

Asst. Prof. Preston MacDougall (1) (Creon Levit/INA)	Dept. of Chemistry Middle Tennessee State Univ.	"A Synthesis of Fluid Dynamics and Quantum Chemistry for the Design of Nanoelectronics"
Asst. Prof. Jesse Maddren (2) (Frank Milo/STM)	Dept. of Mechanical and Aerospace Engineering San Jose State University	"Thermal Property Parameter Estimation of TPS Materials"
Assoc. Prof. Jose Mena-Werth (1) (William Borucki/SST)	Dept. of Physics & Phys. Sci. Univ. of Nebraska, Kearney	"The Dependence of Signal-to-Noise Ratio (S/N) Between Star Brightness and Background on the Filter Used in Images Taken by the Vulcan Photometric Planet-Search Camera"
Professor Ellen Metzger (2) (Geoff Briggs & Jack Marshall/SSX)	Dept. of Geology San Jose State University	"Use of Concept Mapping to Enhance and Update an Educational CD Rom About Mars"
Assoc. Prof. Richard Nemes (2) (John Lekashman/IN)	Dept. of Computer Science Pace University	"Distributed Queries of Large Numerical Data Sets"
Sandra Pizzarello, Ph.D. (1) (George Cooper & Sherwood Chang/SSX)	Dept. of Chemistry and Biochemistry Arizona State University	"Enantiometric Excesses of Acid Labile Amino Acid Precursors of the Murchison Meteorite"
Assoc. Prof. Stephen Pronchick (1) (Frank Milos/STM)	Dept. of Engineering and Technology California Maritime Academy	"An Integrated Tool for the Coupled Thermal and Mechanical Analysis of Pyrolyzing Heatshield Materials"
Asst. Prof. Scot Rafkin (1) (Robert Haberle/SST)	Dept. of Earth System Sci. and Policy Institute Calif. State Univ., Monterey Bay	"Application of the Regional Atmospheric Modeling System to the Martian Atmosphere"
Asst. Prof. Jeffrey Seitz (1) (Jay Skiles & Hector D'Antoni/SGE)	Dept. of Geological Sci. Calif. State Univ., Hayward	"Analysis of the UV-B Regime and Potential Effects on Alfalfa"
Professor Steven Senger (2) (Muriel Ross/SLR)	Dept. of Computer Science and Math University of Wisconsin - La Crosse	"User Directed Tools for Exploiting Expert Knowledge in an Immersive Segmentation and Visualization Environment"
Prof. Hamid Shahnasser (1) (Scott Santiago/Paul Grams/II)	Dept. of Electrical Engineering San Francisco State University	"Simulation of Ames Backbone Network"
Assoc. Prof. Daniel Sheehan (2) (Jeffrey Cuzzi/SST)	Dept. of Physics University of San Diego	"Rossby Waves in the Proplanetary Nebula"
Asst. Prof. Fredrick Sheldon (2) (Michael Lowery/IN)	Dept. of Computer Science University of Colorado	"Composing, Analyzing and Validating Software Models"

Assoc. Prof. Bradley Stone (1) (Louis Allamandola/SSA)	Dept. of Chemistry San Jose State University	"The Identification of Complex Organic Molecules in the Interstellar Medium: Using Lasers and Matrix Isolation Spectroscopy to Simulate the Interstellar Environment"
Professor Frieda Taub (2) (Ed Goolish/Charlie Wade /SLO)	School of Fisheries University of Washington	"Ecological Support of Larval Fish During Multigenerational Studies on Space Station"
Asst. Prof. Joel Thompson (1) (David DesMarais/SSX)	Dept. of Marine Sciences Eckerd College	"Textural and Carbon Isotopic Analyses of Modern Carbonate Microbialites: Possible Ancient and Martian Analogs"
Tom Tucker (1) (Dill Hunley /T)	Instructor, Technical Writing Isothermal Community College	"Harnessing the Brute: The Development of Propulsion-Controlled Aircraft at NASA Dryden"
Asst. Prof. Robin Ward (1) (Marianne McCarthy /T)	Dept. of Mathematics Calif. Polytechnic State	"Making the Learning of Mathematics Meaningful"

(1) Denotes First Year Fellow and (2) Denotes Second Year Fellow

### **SPECIAL COURSE AT STANFORD UNIVERSITY DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS**

**AA298S Seminar on New Science and Technology in the Aerospace Age,**  
 1 unit, Prof. M. Tauber and Visiting Lecturers, held at Stanford University. (See Appendix 1 for listing of program.)

### **SEMINARS AND WORKSHOPS (Appendices 1 - 2)**

The AA298S course took the form of widely-publicized evening lectures at Stanford attended not only by the fellows and their families, but also by the Stanford student registrants in the course as well as by interested members of the local community. Average attendance at these meetings was estimated at about 140 persons. The seminar was also broadcast over the Stanford Instructional Television Network and was thus viewed by students in the off-campus TV classrooms at major local industries such as Lockheed Martin Corporation. Also, most of the lectures were webcast live by the Ames Learning Technologies Channel thus having the potential for reaching an even larger audience.

Serving as the seminar chairman, Professor Tauber introduced the speakers and moderated the discussion and questions from the audience following each presentation. It is worth noting that the well-attended seminars stimulated many favorable comments from persons both from within and outside of the fellowship program. Such response, together with publicity in the local press, constituted favorable "P.R." not only for the program but for NASA and ASEE in general. In accordance with a requested evaluation, the following are samples of the overwhelmingly favorable comments from this year's program:

*"I am a retired engineer from Lockheed Martin Missile Systems Division. This was the third year that I attended. I love these seminars. They afford me a continuing contact with what's new in the aerospace world."*

*"The seminars this summer were outstanding, the best I've listened to in three years. The topics were related to current developments in science, which made them popular, interesting and informative."*

*"These seminars are a valuable service that Stanford provides to those of us who are residents of the local area."*

*"This is an excellent series and, obviously, well attended. In view of the rapid strides being made in astronomy, astronautics, physics, etc., I urge you to continue the series in 1999."*

*"This was a great series. I learned a lot. I missed only one lecture. They were really interesting. It's a great program. Thank you."*

*"Overall, like the series I attended last year, the lectures have proved to be an educational and worthwhile experience. Thank you for making the lectures open to the public."*

*"Thank you so much for the series. I have enjoyed them a great deal."*

*"I just recently discovered the seminars on the internet. I've enjoyed the ones I've seen so far. Please continue to have them."*

*"The two lectures I attended (Dr. McKay and Dr. Drake) were fascinating, and I greatly enjoyed them. The lectures were clear and informative. I wish I learned of the seminar earlier."*

*"This is my third summer to attend these lectures. The topics and speakers have been excellent. Since the age of the audience seems to be spread over 20-90 years, there is a substantial interest in the Stanford and Palo Alto community. It is also nice to be able to review these lectures on the Stanford Channel."*

A second seminar series was keyed more closely to current NASA-Ames programs (see Appendix 2). Each talk was presented by a selected Ames research leader who discussed his/her program in suitable depth. This weekly seminar was held at Ames during the lunch hour, to minimize the fellows' loss of research time. Thus, the participants were given a spectrum of some of the principal areas of R&D and related flight programs currently being emphasized at Ames Research Center. This year's seminar series was advertised via a center-wide email at Ames and, as a result, the talks were standing-room-only even when relocated to a larger conference room. The talks were extremely well received by Center personnel, who seemed to appreciate the opportunity to attend. In conjunction with this seminar series, a comprehensive tour of Ames was arranged which included the four Dryden fellows.

## **WORKSHOP RETREAT AT THE ASILOMAR CONFERENCE CENTER**

**(Appendix 3)**

This was the fourteenth year of the very successful "kick-off" workshop/retreat for the program. The two day meeting took place at the state-owned Asilomar Conference Center in Pacific Grove (see program attached as Appendix 3). The workshop was designed to be somewhat informal, resulting in ample opportunity for interaction with the speakers and among the fellows. The topics chosen were those of special interest to NASA and of importance to the NASA-university relationship. In addition, extended time was allowed for discussion and introduction of alternate thoughts and ideas, as befits a retreat.

As the past meetings have shown, an important feature of the initial workshop-retreat is the opportunity for everyone to become acquainted and for an "esprit de corps to be established. The first full day was devoted to presentations by NASA Ames researchers and managers, and a Stanford faculty member, on space exploration related topics, ecological systems, and application of composite materials. The second day of the program consisted of the research topic reviews of six of the second-year fellows. These brief presentations by the returning fellows were made in response to suggestions and requests by previous participants to learn more about the second year fellows' research topics early in the program.

The workshop/retreat experience generated an enthusiastic momentum among the fellows and contributed to the high morale and camaraderie which carried through the entire summer program. It should be mentioned that the workshop/retreat was run within tight economic limits and that the fellows paid the costs for their spouses and/or children who were in attendance. The co-directors continue to be fully convinced that the workshop/retreat produces a substantial payoff to the fellows and NASA because it enhances their performance in the summer program.

### **PARTICIPATION OF DRYDEN FELLOWS**

Due to the physical distance, fellows at Dryden cannot fully participate in several of the regular activities at Ames Research Center and Stanford. Thus for them, the program is more fully centered on their specific summer R&D project. However, they do participate in major technical activities such as the workshop/retreat and the research reviews, and also attend the closing luncheon banquet of the program. In an on-going effort to increase the involvement of the Dryden Flight Research Center with the summer program, a special tour of the Ames center was arranged to include the Dryden fellows during the first week of the program. In fact, an Ames tour has been made a regular program feature for the Dryden participants. The tours of Dryden by Ames fellows were once again well received by the numerous fellows who took advantage of the opportunity to visit this unique center.

#### **4. RESULTS AND ASSESSMENT OF THE TECHNICAL PROGRAM**

##### **RESEARCH REVIEWS** (Appendix 4)

Communication of technical progress and results took place at a two-day Research Review meeting held at the end of the ninth week of the program. The meeting took the form of 20-minute presentations by the fellows comparable in format to those given at technical society meetings. (See Appendix 4.) Participants included all fellows, NASA colleagues and other interested NASA personnel. These reviews served as the technical core of the interactive part of the program. Participation by the NASA personnel was especially valuable because more perspective was provided on the various subjects. The lively discussions following the talks provided a greater depth of understanding and pinpointed important problems needing further study. In particular, the discussion among fellows and NASA colleagues with widely different specialties helped to reveal the interdisciplinary features of the component sciences and technologies as is required for the optimum performance of aerospace systems.

Each faculty fellow supplements his/her presentation with a brief written summary report that is 3-4 pages long. It is expected that in many cases the contributions of the fellows will form parts of NASA reports and also be written up for publication in the archival literature. The summary reports have been included in the attached Technical Report. Although specific comments on the technical details are not warranted in this Administrative Report, some overall comments about the technical effort are appropriate.

##### **OVERVIEW OF THE ACCOMPLISHMENTS**

As always, the subject coverage was wide indeed, including many branches of engineering and natural sciences in their most modern aspects and applications. In the great majority of instances, both the quantity and quality of the accomplishments were first-class. Many of the research review talks compared favorably with better presentations at most technical society meetings. This fine performance level stems not only from the high intrinsic capability of the fellows (as chosen by the selection process) but also reflects the value of the collaboration with NASA colleagues, who were selected from among the most active and creative R&D technical staff members. (NASA-Ames and NASA-Dryden are fortunate in having such persons.) In our opinion, the accomplishments of the fellows were substantial, especially in view of the limited time of the program -- a conclusion supported by Ames and Dryden technical management.

In retrospect, this program is very fruitful in that it is beneficial both to the fellows and to the Ames and Dryden Centers. As we understand it, the centers are still operating under at least a partial employment "freeze"; thus, the faculty fellow program helps to alleviate somewhat the shortage of highly qualified personnel. In several cases, the fellows are able to look at new problems at the "cutting edge" of the subject, thus helping to crystallize ideas for future mainline research and development. At the same time, NASA is automatically establishing a potentially fruitful university faculty contact pool for future collaboration.

It should be emphasized again that the most essential success-determining factor relates to the *quality* of the fellows' contributions. This was judged in a day-to-day manner by the NASA colleagues. The co-directors and others were able to assess the worth of the contributions from the research review presentations, informal discussions with fellows and colleagues, and the technical write-ups. This year, again, it was clear that the work was of excellent quality, and there is every reason to expect that some of the programs will have a significant impact on the American science and technology scene. A few examples of the impressive efforts and breadths of subjects were those of OSWALDO GARCIA on "The Detection of Polar Stratospheric Clouds Using AVHRR Imagery;" PRESON MACDOUGALL on "A Synthesis of Fluid Dynamics and Quantum Chemistry for the Design of Nanoelectronics"; DANIEL SHEEHAN on "Tanking the Early Solar System"; and FRIEDA TAUB on "Ecological Support of Larval Fish During Multigenerational Studies on Space Station".

Further remarks relative to the assessment are presented in the next section under responses of the NASA colleagues. The positive assessment of the 1998 workshop/retreat was already given in the last section under part 3 above.

Despite repeated requests over the years from both fellows and colleagues, no graduate students could be given awards this year for lack of funds. However, two fellows brought two graduate students each, at their institutions' expense, and the students were included in the program's activities. The students all made technical contributions and benefited from their participation, as in the past. It would be desirable and highly beneficial if a modest amount of funding could be included for graduate students in the future form of the program that is being planned currently by the NASA Headquarters staff.

## **5. EVALUATION BY FELLOWS AND NASA COLLEAGUES**

The fellows were asked to submit responses to a questionnaire prepared by the ASEE, and the colleagues completed another questionnaire prepared by the program staff. Even though the questionnaires may be well-designed, the responses are not always complete. Frank comments were solicited, however, and the responses have been most useful to the co-directors in assessing the program and in pinpointing problems.

### **From the Fellows: Overall Assessment (Appendix 5)**

Responses have been received from all fellows and evaluated. Line C.11 in the questionnaire asks for an overall evaluation of the program. Note that 90% of participants rated the program as "Excellent." In answer to Question B.2, all of the fellows said they would recommend the program "Positively" to their faculty colleagues. Also, the vast majority of fellows rated the seminars highly. It is somewhat incongruous that the few who did not, seldom attended the seminars, or participated in planned group events.

Since it has been our experience that the fellows are quite frank in expressing their opinions of the programs, the response shown above is surely encouraging. The positive response indicated by almost all of this year's fellows is also characteristic of the favorable attitudes of the fellows in previous years. The responses were supplemented by many very positive comments, both verbal and written, from the fellows to the program staff. At the same time some problem areas are recognized, and the fellows have made suggestions for improvements, as discussed in Section II below.

### **From the Fellows: Problems and Suggestions for Improvement**

By now, many of the suggestions are not new, but we continue to pay special attention to the ones that persist, but are not easily implemented. This year, the most common suggestions were the following:

- (i) Lack of affordable housing in the Bay Area.
- (ii) Modification of some of the seminars to include more discussion of the research being performed by fellows.
- (iii) Further funding for follow-up work at home institution is highly desirable.
- (iv) Arrange for at least a limited number of second year fellows to bring a graduate student to participate in the research.

Item (i) is an unfortunate reality of the San Francisco Bay Area (where rents have risen drastically in the past 2-3 years so that one bedroom apartments now cost over \$1,200 per month) and does result in a fair amount of "sticker shock" on the part of the fellows. We were able to offer campus housing, but this was expensive also and not available until two weeks after the beginning of the program. Item (ii) has come up previously. Again this year we had six of the second year fellows present their research reviews early in the summer at the Asilomar workshop. We will continue to facilitate new opportunities for the fellows to interact about their research efforts. Item (iii), is an old story which needs basic involvement on the part of the NASA colleague's branch, but is difficult to do in the current, tight budget situation. However, the fact that over 87% of the fellows stated that they expect to maintain a research relationship with their colleagues (line A.3) is encouraging. Item (iv) is probably our most recurring comment, and resulted in the inclusion of four graduate students who were funded by their home institutions, as previously discussed. However, to include students in the program on an on-going basis will require additional funding and assistance from NASA Headquarters. It was interesting to note that there were less complaints about the stipend than might be expected, although many fellows felt that about a 30% increase would be warranted in this high-cost-of-living area.

The fellows praised the workshop/retreat at Asilomar and a guided tour of the Stanford Linear Accelerator Center. Also well received, and effective in fostering a group spirit, were several social functions. These activities included a guided tour of the Hoover Institution Archives. Lastly, co-director Meredith Moore hosted an end-of-summer luncheon at her home. (Those activities that required fees were paid for by the participants, not the program). Overall, the evaluations were very positive; the completed questionnaires are enclosed in this report as Appendix 5.

## **From the NASA Colleagues: Principal Remarks**

The attempts to involve the NASA colleagues more fully in the Summer Faculty Fellowship Program have to be assessed in light of the otherwise full-time responsibilities of these very active research leaders. Nevertheless, over the past few years, further contact between the co-directors and NASA colleagues has resulted in an increased participation by the latter. This is evident by their more active attendance and discussions at workshops, seminars and social functions. Major relevant comments are, if anything, even more favorable than last year.

- (i) Present format about right.
- (ii) All of the NASA colleagues like the program and are willing to continue their association with it.
- (iii) Several colleagues expressed the desire to extend the program to include a third year.
- (iv) Establish longer term relationship with faculty fellow through grants or consortium agreements. This feature implies the need for more line-item budgeting by the centers.

Examples of the many favorable comments from the NASA colleague evaluation questionnaire (Appendix 6) are as follows:

"NASA gains a great deal by the Stanford Summer Faculty Fellowship Program. It is one of the best ways of bringing outstanding academic talent to NASA Ames for participation in NASA-related research. At the same time, the amazing resources of the Center are made available to academicians who come here -- resources that many universities cannot supply. Exposure to seminars and interactions with other Fellows as well as with Stanford faculty is integral to this program. It is also essential that the Fellows be exposed to the best talent on our own Campus. I cannot suggest improvements to the Program, which I have personally found to be highly successful."

*Muriel Ross  
Life Sciences Division  
Ames Research Center*

"Joel (Henry) is contributing to a problem of major importance within NASA -- the verification and validation of auto-generated software for the control of mission critical functions. NASA Ames wind tunnels utilize this type of software as does the X-33 program, whose integration testbed is located at Dryden. I benefit tremendously from working with Joel and learning the state of the art methods for software analysis."

*Ann Paterson Hine  
Computational Sciences Division  
Ames Research Center*

"This is an opportunity for NASA and academia to know and experience some of each others capabilities and to open those communication lines to help facilitate the flow of information between the two. From my point of view, the Program has been successful and I have no specific recommendations for improvement."

*Mark Collard  
Operations Engineering  
Dryden Flight Research Center*

"This involvement has greatly facilitated my research program on adaptation to simulated altered gravity, a project of obvious relevance to the NASA mission. This is a great program, especially the fact that the fellow can return for a second summer."

*Robert Welch  
Gravitational Research Branch  
Ames Research Center*

"One of NASA's rotorcraft research goals is to develop improved models for the behavior of aeroelastic rotor blades. Prof. Ladkany's expertise in detailed 3-D finite-element modeling does not exist elsewhere at NASA Ames Research Center. The NASA-ASEE program is a cost effective way to bring this expertise into our rotorcraft research program.

*Roger Strawn  
Aeromechanics Branch  
Ames Research Center*

"The program is just excellent. At ARC, we are a very small group of life scientists doing highly focused work. The fellows I have had, including Dr. Liang, not only broaden our perspective, but also bring our research to their communities. My only problem with the program is its brevity!"

*Sara Arnaud  
Gravitational Research Branch  
Ames Research Center*

Through this program I "Obtained a valued, new colleague and collaborator in future research activities; and made research questions of interest to NASA part of the Fellow's interests, which will be transmitted to the students she teaches, therefore furthering interest in gravitational biology."

*Nancy Daunton  
Gravitational Research Branch  
Ames Research Center*

"NASA is investigating, with a team of many researchers in Code I and S, the design of nanoelectronic devices. Dr. MacDougall's work, and our collaboration, is producing significant new knowledge and powerful new tools for the program. He has taught me a huge amount in his area of expertise -- things I desperately wanted to learn."

*Creon Levit  
Numerical Aerospace Simulation  
Systems Division (NAS)  
Ames Research Center*

"Jose's (Prof. Mena-Werth) research at Ames has helped us make progress in our effort to use high precision photometry to find extrasolar planets. The program has been helpful both to Ames and to university researchers in that it gives them the opportunity for active participation in cutting-edge research."

*William Borucki  
Planetary Systems Branch  
Ames Research Center*

"A major goal of NASA is to understand the origin and evolution of life. This research (with Prof. Pizzarello) is directly related to the study of life's origin. The program seems to be a good mechanism for bringing together researchers with similar research interests."

*George Cooper  
Exobiology Branch  
Ames Research Center*

"We have benefited greatly from Dr. Stone's continued collaboration and we now have a first-rate laser system working reliably -- Brad is masterful with its application. Without Brad, the Astrochemical Lab would not have a laser system. I feel the program is excellent."

*Louis Allamendola  
Astrophysics Branch  
Ames Research Center*

"Mesoscale modeling for Mars is in its infancy. Working with Scott (Prof. Rafkin) will increase our capability here at ARC. NASA will benefit from this interaction because the collaboration will produce a unique tool which can be used to support future Mars missions."

*Bob Haberle  
Planetary Systems Branch  
Ames Research Center*

"We are very happy with the program -- we were able to bring in a dedicated researcher to begin work on a problem we've been interested in for years, but unable to assign manpower to. I will continue this work (while consulting with Prof. Pronchick) which is very important to improving our analysis capabilities for spacecraft heatshields."

"The program works very well as is. NASA gets the benefit of a dedicated, well trained scientist who can devote concentrated effort to a particular area, and the fellow obtains first-hand, hands-on experience in a NASA research environment."

*Frank Milos  
Thermal Protection Materials  
and Systems Branch  
Ames Research Center*

"This program offers a valuable and flexible opportunity to enrich all participants in the experience of substantial laboratory interactions over a period of several weeks. In cases where the skill mix between the fellow and the Ames staff is highly complementary yet relevant to the Ames program, the mutual benefits can be outstanding."

*David Des Marais  
Exobiology Branch  
Ames Research Center*

"The results of his research (Tommy Tucker) will be published in a format and language accessible to the non-technical public. Thus it will reach an audience different from that for technical reports and will help the general public understand some of the results of NASA's research. I think this will be of significant benefit to NASA."

*John Dillard Hunley  
Technology Commercialization Office  
Dryden Flight Research Center*

"Dr. Ward was extremely helpful as a partner in refining the process of taking the complex math in NASA's projects and identifying problems suitable for K-12 classroom instruction. She is a creative math teacher. I wish I could take her math education course at Cal Poly!"

*Marianne McCarthy  
Technology Commercialization Office  
Dryden Flight Research Center*

It is clear that the NASA colleagues are nearly unanimously pleased and grateful for the opportunity to have these visiting faculty specialists contributing to their programs. Evidently, the colleagues are highly satisfied with the program as it is. Other suggestions for changes are individual opinions which vary among the respondents. Nevertheless, the co-directors will continue to examine all responses from colleagues and faculty fellows with the intention of further improving the program, where possible.

### **New Opportunities for Faculty Fellows Stemming from the Program**

In almost all cases, the fellows and NASA colleagues have shown a mutual interest in follow-up work. This has taken the form of proposal planning, written proposals, and/or continuation of existing grants. A large number of publications are in progress as well, although their appearance will take a little more time. The NASA colleagues of second year fellows were asked what, if any, future plans they had for follow-up with their fellows. Of the colleagues, 87% reported that they intend to continue their collaboration with the fellows.

NASA colleagues and fellows also anticipate submitting publications to the following journals:

*American Journal of Physiology*  
*AIAA Journal of Spacecraft and Rockets*  
*Aviation, Space and Environmental Medicine*  
*Cryogenics*  
*ICARUS - International Journal of Solar System Studies*  
*IEEE (Comp. Systems) Journal*  
*International Journal of Remote Sensing*  
*Journal of Geophysical Research - Planets*  
*Journal of Bone and Mineral Research*  
*Journal of Physical Chemistry*  
*Nature*  
*Photochemistry and Photobiology*  
*Science*

and present their findings at the following major technical society meetings:

*Airborne Remote Sensing Symposium*  
*Aerospace Medicine Association*  
*American Astronomical Society*  
*American College of Sports Medicine*  
*American Institute of Aeronautics & Astronautics Technical Meeting*  
*American Institute of Aeronautics & Astronautics Thermophysics Conference*  
*IEEE Technical Meeting -WESCON*  
*Geological Society of America*  
*Gordon Conference*  
*INTERCOL*  
*Space Cryogenics*  
*Visible Human Conference*  
*Workshop on High-Precision Photometry*

## **6. PERSPECTIVE ON THE OVERALL OPERATIONAL LOGISTICS**

Operation of this program has many of the features of a university admissions program. For the record, we review the sequence briefly, starting from receipt of applications:

- (i) Applications analyzed and processed by Stanford and transmitted to NASA research managers for review.
- (ii) Selection made - application materials returned to Stanford.
- (iii) Notification of awards by Stanford, including relocation and travel allowances, housing information, etc.
- (iv) NASA colleagues and selected summer fellows discuss possible research projects via telephone/e-mail programs; occasionally a visit is arranged.
- (v) Ongoing planning activity by co-directors and administrators, organizing seminars, workshops, arranging housing, social events, etc.
- (vi) Orientation meeting on the first Monday morning of the program, including distribution of all announcements, workshop agenda, seminars, social events, etc.
- (vii) Tour of Ames facilities that same week.
- (viii) Retreat-Workshop - second week.
- (ix) Course/seminar programs (see details earlier in this report.)
- (x) Two-day session of Research Reviews.
- (xi) Dryden fellows come to Ames for Research Reviews and to attend a group luncheon during the second week in August.
- (xii) Submission of completed evaluation questionnaires by fellows and by NASA colleagues to program staff.
- (xiii) Submission of Abstract/Summary Reports by fellows to program staff.
- (xiv) Assessment by co-directors of the program just completed and writing, compilation and submission of Administrative and Technical Report to NASA Headquarters and the ASEE.
- (xv) Writing and submission of proposal for following year's program to NASA Headquarters and the ASEE.
- (xvi) Co-directors and administrators participate in annual review and planning meeting with ASEE, NASA headquarters management and ASEE officials.

With some variation over the years, the above logistics have served the program well. The formulation is sufficiently flexible to absorb modifications and improvements in either the technical program or general arrangement.

## **7. CONCLUDING REMARKS AND RECOMMENDATIONS**

Within the context of all the considerations presented above, one feature of this program stands out. In a very positive way it serves both the interests of NASA's Ames and Dryden Research Centers and also of the faculty fellows representing a diversity of academic communities. Therefore, this program benefits a significant cross section of the higher educational scene in this country. Very directly, and at a high intellectual level, the program implements NASA's stated policy of maintaining mutually enriching relations with the university community that also contribute to the agency's research and applications programs in a concrete manner. The Summer Faculty Fellowship Program is unique in this respect.

Also deserving emphasis is the fact that the acceptance of summer faculty fellows has grown very selective during recent years. The selection of 15 first year fellows from a strong applicant pool of 55 resulted in a very high-caliber group. Although many are at a relatively early stage of their careers, some are in mid-career and a few are already rather well known.

Three weeks prior to the beginning of our program, funding was provided for a fellow under the ALERT program. However, the addition of the ALERT fellow was offset by the last minute cancellation, for family medical reasons, by a previously chosen fellow. As a result, the total number of new participants remained at 15. (Since there was not enough time to award the canceled fellowship to another candidate, the funds were used to supplement the relocation allowance of Ames fellows to help compensate for the very high local housing cost that exceed \$1,200 per month for small one-bedroom apartments.)

A continuing concern relates to the relatively small numbers of minority persons in our applicant pool. This is partly a geographical problem since there are no historically African-American colleges and very few minority colleges in California. Although the Hispanic population in California is extensive, the fraction at the college faculty level is evidently still small. A positive feature was the inclusion of three Hispanics and seven women in this year's program. An active effort is continuing to recruit more minority applicants in the future.

In earlier reports, we have quoted very strong approval of the program by the past and present directors of the Ames Research Center, and at all levels of NASA management. The same is true of the Stanford University administration. It is important to note that such management support continues as strong as ever after more than 30 years. During that period, several modifications have improved the program's effectiveness. Within a successful overall framework, the co-directors and program staff continue to seek further improvements.

Two features which are basically important for the success of the present program, but which need careful planning on a year-to-year basis, are: (1) suitable coordination of the role of the NASA colleagues, and (2) optimizing the specialty mix among the most highly-qualified applicants, e.g., research scientists along with those who do engineering technology.

We repeat a recommendation from previous years, namely that a selected number of second-year fellows (perhaps two, or three) receive supplementary funding to bring an advanced graduate research student to participate in the summer's technical work. The positive results from such an arrangement were self-evident this summer. It would seem appropriate, if necessary, for the center in question to contribute part of this extra cost. Obviously, this is a decision that NASA management must make.

We think it is evident that the Summer Faculty Fellowship Program represents a worthwhile investment on the part of NASA. The three-way collaboration among NASA, ASEE and Stanford represents a successful arrangement. For the various reasons discussed in this report, it appears that the program deserves to be continued essentially in its present format.

## APPENDICES

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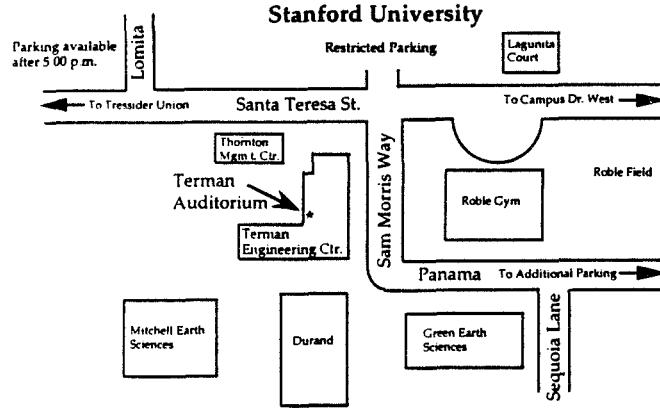
STANFORD UNIVERSITY  
DEPARTMENT OF AERONAUTICS & ASTRONAUTICS

**NASA-ASEE-Stanford Seminars  
New Science and Technology in  
the Aerospace Age**

**Summer 1998**

**Thursdays, 8:00 p.m. - Terman Auditorium**

- 
- June 25      **Mr. MICHAEL GREEN**, X-33 Project Manager,  
Office of the Director of Space;  
NASA Ames Research Center  
"NASA's Reusable Launch Vehicle Program"
- July 2        **MR. G. SCOTT HUBBARD**, Associate Director, Space:  
NASA Ames Research Center  
"The Lunar Prospector Mission: Concept and Early Results"
- July 9        **DR. EDWIN ERICKSON**, Research Scientist, Astrophysics Branch;  
NASA Ames Research Center  
"The Decade(s) of Infra-Red Astronomy"
- July 16       **DR. DALLAS DENERY**, Deputy Chief of Air Traffic Management;  
NASA Ames Research Center  
"The Future in Air Traffic Management"
- July 23       **DR. CHRISTOPHER MCKAY**, Research Scientist,  
Planetary Systems Branch;  
NASA Ames Research Center  
"The Search for Life on Mars and Beyond"
- July 30       **DR. FRANK DRAKE**, President;  
The Search for Extra-Terrestrial Intelligence Institute  
"The Search for Extra-Terrestrial Intelligence"
- August 6      **DR. MICHAEL CARR**, Chief, Astrobiology Branch;  
The United States Geological Survey  
"Early Results from Mars Global Surveyor"
- 



**Public Invited  
To Attend**

No Charge for Admission.  
Reservations are not required.  
Please Note: Unless posted as  
a "24 hour enforced" area,  
campus parking restrictions are  
not enforced after 5:00 p.m.

This seminar (AA298S)  
is available to Stanford  
students for one unit of  
credit (call 723-3328).

**1998 NASA-ASEE Stanford  
Summer Faculty Fellowship Program**

**Seminars on Current Research  
in the Aerospace Sciences**

**NASA-Ames Research Center  
Tuesdays, 12:00 Noon - 1:00 P.M.**

- June 23**      **Dr. Malcolm Cohen**  
*Gravitational Research Branch*  
"Human Adaptation to Space Flight: The Big Picture"  
Location: Bldg. 245, Auditorium
- July 7**      **Dr. Robert Welch**  
*Life Sciences Division*  
"Mars Gravity Simulator"  
Location: Bldg. 233, Room 172
- July 14**      **Dr. Charles Wade**  
*Life Sciences Division*  
"Space Station Biological Research Project: Expansion  
of Fundamental Biological Knowledge"  
Location: Bldg. 233, Room 172  
1:00 - 1:20      Research Review by Prof. Joel Thompson
- July 21**      **Dr. Robert Haberle**  
*Planetary Systems Branch*  
"Mars Pathfinder"  
Location: Bldg. 233, Room 172  
1:00 - 1:20      Beatrice Morales, Ames Grants Officer  
NASA Grants and Follow-on Funding
- July 28**      **No Seminar -- Stanford Linear Accelerator Center Tour**  
1:00 - 3:00 p.m.   Meet at 12:20 Near the Ames Visitor  
Center Space Shuttle Model to arrange car pools.  
2575 Sand Hill Road, Menlo Park

**1998 NASA-ASEE Summer Faculty Fellowship Program  
at NASA-Ames Research Center and  
NASA-Dryden Flight Research Center**

**WORKSHOP RETREAT**

**JUNE 28-30, 1998**

**AT ASILOMAR CONFERENCE CENTER**

800 Asilomar Blvd., Pacific Grove, California  
Telephone: (408) 372-8016

**AGENDA**

**Sunday, June 28th**

3:00 - 4:30 p.m.	Registration is at the NASA-Stanford Desk. For spouses and children, please make your check payable to "Asilomar Conference Center" and give it to Melinda Francis. Meal tickets and room keys will be available at the main desk for those who arrive after 4:15 p.m. on Sunday. A \$1.00 refundable key deposit will be required.	Administration Bldg.
6:00 p.m.	Dinner	Crocker Dining Hall
8:00...	Social & Hospitality Room	Pinecrest

**Monday, June 29th**

7:30 a.m.	Breakfast	Crocker Dining Hall
9:00 - 10:10 a.m.	"Lunar Prospector Science Results" Dr. Alan Binder President, Lunar Research Institute	Scripps
10:10 - 10:30 a.m.	Coffee Break	
10:30 - 11:40 a.m.	"Planetary Entry Vehicle Design for Future NASA Missions" Mr. Paul Wercinski Chief, Reacting Flows Environments Branch NASA Ames Research Center	Scripps
12:00 Noon	Lunch	Crocker Dining Hall
1:30 - 2:40 p.m.	"Composite Materials: From the Space Shuttle to Davies Symphony Hall" Dr. George Springer Chairman, Department of Aeronautics & Astronautics Stanford University	Scripps
2:40 - 3:00 p.m.	Coffee Break	

3:00 - 4:10 p.m.	<b>"Rapid Rates of Change and Emergent Ecosystem Properties"</b> Mr. David Peterson Chief, Ecosystem Science and Technology Branch NASA Ames Research Center	Scripps
6:00 p.m.	Dinner	Crocker Dining Hall
8:00 p.m.	Social & Hospitality Room	Pinecrest

### Tuesday, June 30th

7:30 a.m.	Breakfast	Crocker Dining Hall
9:00 a.m.	Research Reviews by Second Year Fellows	Scripps
	9:00 - 9:20 a.m. Daniel Sheehan	<b>"Tanking the Early Solar System"</b>
	9:20 - 9:40 a.m. Ellen Metzger	<b>"Minerals as Planetary Memory: The Case for In-Situ X-ray Diffraction Analysis on Mars"</b>
	9:40-10:00 a.m. Steven Senger	<b>"An Immersive Environment for the Direct Visualization and Segmentation of Large Volumetric Data Set"</b>
10:00 - 10:10 a.m.	Group Photo	
10:10 - 10:30 a.m.	Coffee Break	
	10:30 - 10:50 a.m. Mary Sue Lowery	<b>"Hypergravity Effects on Rat Hindlimb Muscle"</b>
	10:50 - 11:10 a.m. Jesse Maddren	<b>"Thermal Property Parameter Estimation from Lagged Temperature Data"</b>
	11:10 - 11:30 a.m. Samaan Ladkany	<b>"Fluid Structure Interaction in the Application of Rotorcraft and Windmills"</b>
< 12:00 Noon	Checkout; return keys to main desk for refund of your key deposit.	Administration Bldg.
12:00 Noon	Lunch	Crocker Dining Hall (or box lunch if ordered in advance)

Workshop Adjourned

**NASA Summer Faculty Fellowship Program  
1998 Research Reviews**

**August 10th and 11th**

**NASA-Ames Research Center  
Bldg. 245, Second Floor Auditorium**

Opening remarks by research colleagues, 15 minute presentation of research followed by a 5 minute discussion period.

**Monday, August 10th**

8:30 - 8:40 a.m.	Opening Remarks by Program Co-Director Mike Tauber	
8:40 - 9:00 a.m.	Paul Herrick "F18 Life Support - APECS and ECIX Cockpit Integration"	<i>Mike Arebalo (OE)</i>
9:00 - 9:20 a.m.	Amanie Abdelmessih "Experimental Measurements of Temperature and Heat Flux in a High Temperature Black Body"	<i>Tom Horn (RS)</i>
9:20 - 9:40 a.m.	Tom Tucker "Harnessing the Brute: The Development of Propulsion-Controlled Aircraft at NASA Dryden"	<i>Dill Hunley (T)</i>
9:40 - 10:00 a.m.	Robin Ward "Making the Learning of Mathematics Meaningful"	<i>Marianne McCarthy (T)</i>
10:00 - 10:20 a.m.	Break	
10:20 - 10:40 a.m.	Richard Nemes "Distributed Queries of Large Numerical Data Sets"	<i>John Lekashman (IN)</i>
10:40 - 11:00 a.m.	Preston MacDougall "A Synthesis of Fluid Dynamics and Quantum Chemistry For the Design on Nanoelectronics"	<i>Creon Levit (INA)</i>
11:00 - 11:45 a.m.	Kevin Whitaker, SFFP Opportunity National Opportunities for Visionary Academics (NOVA) Program A national pre-service program to improve the preparation of pre-service teachers in science, mathematics and technology by creating change in higher education.	
12:00 - 1:30 p.m.	Luncheon at Meredith Moore's (1426 Franchere Place, Sunnyvale)	

1:45 - 2:05 p.m.	Jane Friedman "Using Amphion in Education over the World Wide Net"	<i>Michael Lowery (IC)</i>
2:05 - 2:25 p.m.	Joel Henry "Testing and Troubleshooting Embedded Real-Time Software"	<i>Ann Patterson-Hine (IC)</i>
2:25 - 2:45 p.m.	Fredrick Sheldon "Using Models of Software to Assess the Performability and Reliability of Competing Design Candidates "	<i>Michael Lowery (IN)</i>
2:45 - 3:05 p.m.	Hamid Shahnasser "Simulation of Ames Campus Network"	<i>Scott Santiago/Paul Grams (II)</i>
3:05 - 3:20 p.m.	Break	
3:20 - 3:40 p.m.	Stephen Pronchick "An Integrated Tool for the Coupled Thermal and Mechanical Analysis of Pyrolyzing Heatshield Materials"	<i>Frank Milos (STM)</i>
3:40 - 4:00 p.m.	Michael Lambert "Measuring Thermal Conductivity and Moisture Absorption of Cryo-Insulation Materials"	<i>Louis Salerno/Susan White (STM)</i>
4:00 - 4:20 p.m.	Oswaldo Garcia "The Detection of Polar Stratospheric Clouds Using AVHRR Imagery"	<i>R. Steve Hipskind (SGG)</i>
4:20 - 4:40 pm.	Stanley Herwitz "High Resolution Airborne Digital Imagery for Precision Agriculture"	<i>Robert Slye (SG)</i>
4:40 - 5:00 p.m.	Jeffrey Seitz "Analysis of the UV-B Regime and Potential Effects on Alfalfa"	<i>Jay Skiles/Hector D'Antoni (SGE)</i>
5:00 p.m.	Adjourn	

**Tuesday, August 11th**

9:00 - 9:20 a.m.	Jose Mena-Werth "The Dependence of the Signal-to-Noise Ratio Between Star Brightness and Background on the Filter Used in Images Taken by the Vulcan Photometric Planet-Search Camera"	<i>William Borucki (SST)</i>
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9:20 - 9:40 a.m.	Scot Rafkin "RAMS Goes to Mars"	<i>Robert Haberle (SST)</i>
9:40 - 10:00 a.m.	Sandra Pizzarello "Enantiomeric Excesses in the Murchison Meteorite: New Analyses and Data"	<i>George Cooper/Sherwood Chang (SSX)</i>
10:00 - 10:20 a.m.	Bradley Stone "The Identification of Complex Organic Molecules in the Interstellar Medium: Using Lasers and Matrix Isolation Spectroscopy in the Laboratory to Simulate the Interstellar Environment"	<i>Louis Allamandola (SSA)</i>
10:20 - 10:40 a.m.	Phil Kesten "Cosmochemistry: Synthesis and Analysis of Organic Material from Planetary Ices"	<i>Yvonne Pendleton/Dale Cruikshak (SST)</i>
10:40 - 10:55 a.m.	Break	
10:55 - 11:15 a.m.	Cesar Compadre "Virtual Reality Simulation of the Effects of Microgravity in Gastrointestinal Physiology"	<i>Muriel Ross (SL)</i>
11:15 - 11:35 p.m.	Gene Korienek "The Mars Gravity Simulator: Strategy and Preliminary Data"	<i>Robert Welch (SL)</i>
11:35 - 11:55 p.m.	Michael Liang "Bone Strength in Rats Fed High Salt Diets During Exposure to a Space Flight Model"	<i>Sara Arnaud (SLR)</i>
11:55 - 12:15 p.m.	Frieda Taub "Ecological Support of Larval Fish During Multigenerational Studies on Space Station"	<i>Ed Goolish/Charlie Wade (SLO)</i>
12:15 p.m.	Adjourn	

**1998 NASA Summer Faculty Fellowship Program  
at Ames Research Center and Dryden Flight Research Center**

**Evaluation Responses from Faculty Participants**

**A. PROGRAM OBJECTIVES**

1. Are you thoroughly familiar with the research objectives of the research (laboratory) division you worked with this summer?

Yes      31

No        

• Yes, somewhat. • I was never clear on the division (research lab vs. division).

2. Do you feel that you were engaged in research of importance to your Center and to NASA?

Yes      29

No      1

Don't Know      1

• No, I often felt that I was "spinning my wheels" and am totally uncertain as to how or if my efforts will be incorporated into on-going work at Ames Research Center.

3. Is it probable that you will have a continuing research relationship with the research (laboratory) division that you worked with this summer?

Yes      26

No      1

Uncertain      4

• Uncertain, I would like to.

4. My research colleague and I have discussed follow-up work including preparation of a proposal to support future studies at my home institution, or at a NASA Center.

Yes      26

No      4

• Yes, but not a proposal. • Yes, on the CCU - Euglena Project.

5. Are you interested in maintaining a continuing research relationship with the research (laboratory) division that you worked with this summer?

Yes 31

No   

- Yes, but I don't feel that there is a clear definition of the project.

## B. PERSONAL PROFESSIONAL DEVELOPMENT

1. To what extent do you think your research interests and capabilities have been affected by this summer's experience? (you may check more than one)

Reinvigorated 20

Redirected 14

Advanced 18

Barely Maintained   

Unaffected   

2. How strongly would you recommend this program to your faculty colleagues as a favorable means of advancing their personal professional development as researchers and teachers?

Positively 31

Not at all   

- I already have -- to an evolutionary biologist.
- Yes, if the project and working situation/facilities are clearly understood by all.

3. How will this experience affect your teaching in ways that will be valuable to your students? (you may check more than one)

By integrating new information into courses 28

By starting new courses 7

By sharing research experiences 27

By revealing opportunities for future employment in government agencies 14

By deepening your own grasp and enthusiasm 13

Will affect my teaching little, if at all 1

- By starting new courses, if approved by the university committee.
- Sharing research experiences, only on the graduate level in my case!
- Will affect my teaching little if at all -- I am research faculty.
- Maybe starting new courses.
- Most definitely by integrating new information into courses.

4. Do you have reason to believe that those in your institution who make decisions on promotion and tenure will give you credit for selection and participation in this highly competitive national program?

Yes 17

No 1

Don't Know 3

N/A (i.e., already have tenure) 10

- I would strongly recommend that the Project Director send a letter to the Provost or Academic V.P. at the home institutions of the fellows giving their names and the competitive nature of the program, cc: Dean and Dept. Chair.
- Don't know, I hope so.
- No, FYI, I had my review (post one year from initial hiring last fall-spring 97-98, it was long and drawn out) and the results were a one year reappointment (vs. 2 yr.). I heard lots of talk, but there was a letter that clearly stated that both my teaching and research were a serious concern. Personally, I know it (the ASEE) was the best thing for me, and I have absolutely no second thoughts. My gut feeling toward the T/P process is that they didn't care... and that it boils down to student surveys and publication beans... neither of which the previous year of working there I had much to show. To "them" the NASA/ASEE was noise. The message was loud and clear -- publish or perish and be a better teacher (make your students happy!).
- N/A, full prof. (but having won (earned?) a place in a competitive program and (if) I get the contract -- it will count).
- Already have tenure, but would be considered for promotion.

## C. ADMINISTRATION

1. How did you learn about the Program? (Please check appropriate response)

12 Received announcement in the mail

3 Read about it in a professional publication.

14 Heard about it from a colleague.

1 Read about it on the World Wide Web.

5 Other (explain)

- ASEE Prism.
- Dr. Ross, my research colleague, gave the information about the program.
- Received announcement in mail (from Dean's Office).
- Institutional Research Office staff.
- From Grants & Contracts Support Office.
- Heard about it from a colleague (different from my collaborator this summer, but who also works at Ames).
- Other, 2nd year fellow.
- Other, my advisor who participated at JPL years ago. I also know that my chairman (where I graduated) did it too.
- Was in the program previously, and was invited to re-apply.

2. Did you also apply to other summer faculty fellowship programs?

5 Yes      26 No

If yes, please indicate from which:

- |          |                     |
|----------|---------------------|
| <u>1</u> | DOE                 |
| <u>2</u> | Another NASA Center |
| <u>1</u> | Air Force           |
| <u> </u> | Army                |
| <u>2</u> | Navy                |

- Navy, the initial year and was offered a position. This year I was so busy that I forgot about it until my colleague got in touch with me.
3. Did you receive an additional offer of appointment from one or more of the above?  
Yes 2 No 8 N/A 20

If yes, please indicate from which:

- |          |                     |
|----------|---------------------|
| <u>1</u> | DOE                 |
| <u> </u> | Another NASA Center |
| <u> </u> | Air Force           |
| <u> </u> | Army                |
| <u>1</u> | Navy                |

- The Navy in 1997 (but I am a second year fellow).
4. Did you develop new areas of research interest as a result of your interaction with your Center and laboratory colleagues?

- |       |           |
|-------|-----------|
| Many  | <u>9</u>  |
| A Few | <u>22</u> |
| None  | <u> </u>  |

- A few, mostly I had success developing our preliminary concepts into a more convincing theory.
  - A few is enough!
  - A few, mainly advanced concepts.
5. Is the current stipend (\$1,000 per week) sufficient for you to consider returning as a fellow next summer?

- |     |           |
|-----|-----------|
| Yes | <u>21</u> |
| No  | <u>5</u>  |

If not, why

- I will return for the research. But money wise I expect to end either even or slightly on the negative. In addition to keeping my home and normal expenses (not taken in estimating my expenses), I have to rent a fully furnished apartment and a car. Not to mention other supplies. Also, I will have to pay taxes on money that never stayed in my pocket as assumed earnings.
- Not applicable, I am a second year fellow.
- Yes, I will return next summer but I think the stipend should be raised.
- The stipend should be increased. In my case money was not an object, I would have come for free.
- No, expensive to live in the Bay Area i.e., housing, airfare, local travel, etc.
- Yes, however, housing in this area is quite expensive and greatly exceeds the housing allowance.
- Yes, unless the cost of living increases in the Bay Area. It

was barely enough for my family at current rent levels, etc.... • No, cost of living in the Bay Area is a serious obstacle to participation in the NASA/Ames SFFP. • Yes, I'd like to see the stipend increased, but value the experience. • No, cost of living in San Francisco Bay Area is high! • No, my wife did not like my living situation. She went home and told me that she did not want me to come back unless I secured a place with a kitchen, air conditioning and a private bath. I found a place (Homestead Village) that could provide such amenities at ~\$450/wk (maybe slightly less) which comes to about half my weekly stipend. I think the figure should be about 25%. Given we received a housing allowance this rough calculation is somewhat mitigated in favor of being fair. • Yes, but I found that in coming here, bringing my family, paying expenses here, and paying expenses on my permanent residence, it was a bit of a loss financially.

6. Did you receive any informal or formal instructions about submission of research proposals to continue your research at your home institution?

Yes 23                  No 8

- Yes, from B. Morales at Ames.

7. Was the housing and programmatic information supplied prior to the start of this summer's program adequate for your needs?

Yes 27                  No 1                  Checked Both Yes & No 2

- Suggestion for the future: Survey Dryden participants, where they stayed -- was it adequate for a family, what type of air conditioning, rates paid, etc. • More web-based information could be given, such as URL for rental searches. • O.K., but not really helpful enough.

8. Was the contact with your research colleague prior to the start of the program adequate?

Yes 29                  No 2

- Yes, very much so. • With Ed Goolish, yes.

9. How do you rate the seminar program?

Excellent	<u>19</u>
Good	<u>9</u>
Fair	<u>2</u>
Poor	<u>  </u>
N/A	<u>1</u>

- Fair, too many people attended. I couldn't even get in the room.... • Excellent, except for cost of living in Silicon Valley.

10. In terms of the activities that were related to your research assignment, how would you describe them on the following scale?

Check one per activity	Time Was				
	Adequate	Too Brief	Excessive	Ideal	N/A
Research	22	3		6	
Lectures	16		1	10	2
Tours	17	3		9	1
Social Recreational	19	4		6	
Meetings	22			7	

Comments:

- The only ones available to Dryden were the Monterey lectures and the final presentation.
- The talks were excellent this year. I would say on the whole, better than last year. The social activities are very important, we gain a lot from our interactions with the other fellows.
- Increased lab/facility tours would be beneficial.
- Suggest that the program administrators keep reminding the NASA research hosts, who are super busy, to contact the fellows and make arrangements for their arrival to Ames.
- I enjoyed the tour of SLAC as well as the weekly lectures on current NASA research. The end of summer luncheon was an especially nice touch.
- The Ames tour would have been more worthwhile if some demonstrations were given (not much occurred, just "talking heads").
- The summer is so short, it was hard to find time to do everything.
- Last year I participated in most of the activities. This year I went to 4 lectures and Asilomar. As you can tell from my prior comments that I really could not have afforded much more. But I do appreciate their availability.
- Ten weeks in the summer always seems to go by too quickly in terms of the amount of time one can spend on research. Fortunately, I will be able to continue working on this project during the academic year.
- There is never enough time!
- I have no problem with time set aside as needed for activities -- NASA Dryden was very flexible.

11. What is your overall evaluation of the program?

Excellent	<u>28</u>
Good	<u>3</u>
Fair	<u> </u>
Poor	<u> </u>

12. If you can, please identify one or two significant steps to improve the program.

- Provide clearer guidelines for faculty fellows and NASA colleagues -- detailed responsibilities and expectations.
- Flexible start/end dates to allow for varying semester/summer start/end dates.
- 1.) Provide for a 1 week visit with colleagues between 1st and 2nd year to discuss status of project. 2.) Increase to 12 weeks.
- The NASA branches who accept to host fellows should have some funding available for the fellow to take home as a research grant. At least assign the fellow to a NASA researcher who is ready to write joint proposals with the fellow!
- The SFFP is very well run, and I have no suggestions for significant

improvement, since none are necessary. • If possible, pre-arrange office space and p.c. to be used in conjunction with the research activity i.e., for data analysis, e-mail, writing and graphics. • Encourage mentors to spend more time talking to participants before their arrival and making certain that adequate projects are ready to go as soon as the participants arrive. • 1.) Increase the stipend and relocation allowance. 2.) Try to convince the technical contracts at Ames to arrange for demonstrations at the sites on the Ames tour. • The program is excellent. • I believe the organization of activities such as tours and lectures were superb. Much thought and planning went into this aspect of the program. The individuals directing the program (Mike Tauber, Melinda Francis, Meredith Moore, and Marilyn Jackson) were kind and nice and patient. I hope the program continues. • I really like this program and the exciting experiences it has to offer. I have learned a great deal, and value my new interests in planetary geology. However, superimposed on these positive thoughts is a sense of frustration and dissatisfaction. This discontent arises from two sources: 1.) lack of good communication with my colleagues and 2.) inadequacy of computing facilities and maintenance. I was often torn between my obligation to be on-site and the realization that I didn't have the hardware and/or software needed to do this job. • Cannot identify any. • Interdisciplinary exchanges are becoming more and more important. Informal social/science meetings (of the type used in Monterey) between fellows could be introduced in place of all social ones. • I would enjoy the lectures much more if they were not so remedial. Give me science! Where is the beef??? • This is not a criticism, but perhaps the dates of the fellowship could be made flexible or changed so that it works better for faculty from schools on the semester and quarter systems. I started the fellowship 1 1/2 weeks before the end of our spring quarter term which was a major inconvenience. • Try to get the fellows adequate office space in which to work. My "cubicle" was a storage area for residents and I always felt cramped. • Housing - \$ • Can't think of any ways to improve it! Please, just keep it going. This program is invaluable to faculty -- both for allowing us to keep our research going and for the impact it has with respect to teaching. • 1.) I would have liked even more informal time with other fellows. 2.) More info on availability of equipment before project started. • None, program is very good. • Not able to think of any items in need of improvement.

13. For second-year fellows only. Please use this space for suggestions on improving the second year.

- Make sure that the research area is well defined and that funding prospects are good. Encourage the NASA hosts to involve the Fellows in the preparation of research grants.
- Encourage mentors to maintain more contact between the two summers to maximize research time available. • The program is excellent. • Stress communication; introduce some scheduling flexibility (there were days when I could have been more productive working on a computer elsewhere). • Second year was as excellent as the first year. • I really have no specific suggestion under the given constraints I think the program is very effective and well managed.
- This year was very stimulating with the group I was assigned. There were weekly - bi-weekly meetings which usually included a technical/programmatic talk/discussion and/or both! We had visitors from other NASA centers and outside academics (mostly foreign). I was an outstanding program... stimulating and enlightening. I would recommend it as a model. • No comments. The time pinch is part of research.

#### D. STIPEND

1. To assist us in planning for appropriate stipends in the future would you indicated your salary (on an academic year basis) at your home institution.

\$ 54,149 (average of 28 of 31 responses)

2. Is the amount of the stipend the primary motivator to your participation in the NASA Summer Faculty Fellowship Program?

Yes 4 No 16 In part 9

3. What, in your opinion, is an adequate stipend for the ten-week program during the summer of 1999?

<u>1</u>	\$10K	<u>2</u>	\$14K
<u>1</u>	\$11K	<u>10</u>	\$15K
<u>7</u>	\$12K	<u>4</u>	Other, please specify: _____
<u>3</u>	\$13K		_____

- Housing costs are very high here. Perhaps the relocation allowance should be increased.
- Other, obviously more is better, but \$10K seems adequate.
- \$1,500 per week minimum and travel expense.
- Plus a greater allowance for relocation, especially for families.
- Other, adjusted to the cost of renting.
- \$12K, due to the cost of housing.
- \$15K + living differential of 2.5K/10 wks. based on what I would expect from a for-profit organization.

#### PLEASE USE THE PAGE FOR YOUR COMMENTS TO ANY QUESTION

- Suggestion for next year: At the Monterey retreat include information about 1.) how to get my students hired at NASA and 2.) how to start a co-op program at my school with NASA.
- The organizers and administrators of the program did an outstanding job. I enjoyed this summer experience and it has been very beneficial for my research.
- The program administrators have done a first rate job again this year. Mike, Melinda, Marilyn and Meredith do a terrific job running this program -- they're great!!!
- One problem did occur this summer, the telecommunications contractor at Dryden was unable to connect my computer to the net prior to the end of the program. As a result, I was unable to access the keyserver to use any program. Colleagues in my branch were very helpful by granting me access to their machines, but having one on my desk would have been best. Additionally, the contractor took 5 weeks to install a phone at my desk and another week to provide voice mail. Again, my colleagues provided access to their phones but this did slow progress on my project. In the future would it be possible for the ASEE program director to check with colleagues to see if access arrangements have been made? (A side note: Last summer phone and computer accesss were provided without delay. This summer may have been only an isolated problem.) Thanks.

- This is a very beneficial program. I look forward to next summer.
- Should make the stipend variable. Ask the fellows for their academic monthly salaries, make sure that the stipend does not exceed their normal salaries plus benefits. Remember how expensive life is around here!
- It is very important to all ASEE fellows to have a letter from Michael Tauber, co-director of the Program, sent to respective institutions', deans or vice-presidents. A letter of reference regarding the individual fellow's success and hard work, contribution, etc. at NASA and its colleagues.
- Mike Tauber, Melinda Francis, Meredith Moore, and Marilyn Jackson made this a memorable and enjoyable summer. The SFFP has provided me with an intellectually stimulating environment. I will be a better teacher because of it. Thank you to NASA, the ASEE, and Stanford University for supporting the SFFP.
- Overall, this program is well-conceived and well-managed. Thanks for your efforts.
- I had a wonderful, rich experience. Thank you so much!
- I believe that the ASEE program was very beneficial to me in terms of learning regardless of any follow-up opportunities. This year code IC resources were really stretched because they were in the process of hiring lots of people as compared to the past year. I had some visitors (a student and colleague) and we got desperate to even find a chair. Actually, I was quite impressed at their ability to satisfy my needs under the circumstances. They were very helpful. There definitely is a lack of space there in Code IC. Mike Lowry, Mark Boyd, Klaus Havelund, Santos Lazzeri and the other members of ASE group provided valuable comments and discussion with respect to my research agenda. It was a privilege working with this group.
- Great program! Superbly organized -- Stanford lives up to the "class act" that we expect from a university of its stature. One suggestion: Despite the request to keep research reviews to 15 minutes, and 5 minutes for questions -- a few fellows took considerably more time than this. Perhaps a buzzer, or warning light, would be useful to keep on schedule.
- Housing proved unexpectedly expensive in Lancaster, CA, and several weeks after moving my family into our apartment, I felt the complex was less than desirable and had some iffy characters. An increase in stipend might help me upgrade and improve this situation next summer.
- This summer faculty workshop afforded me the opportunity to meet wonderfully talented people who will serve as colleagues to me in the future. Thank you for this opportunity!

**NASA Stanford Summer Faculty Fellowship Program  
at Ames Research Center and Dryden Flight Research Center**

**1998 NASA-Colleague Evaluation**

1. Name of Faculty Fellow \_\_\_\_\_

2. Your Name \_\_\_\_\_

3. Branch / Division \_\_\_\_\_

4. Indicate briefly the subject area of the fellow's research:

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5. What are the fellow's demonstrated major strengths (e.g., familiarity with the latest techniques in computational fluid dynamics; or "hands-on" capability in laboratory experimentation with sophisticated electronic equipment; etc.)?

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6. Please characterize the personal contact between yourself and the fellow prior to the start of the summer program?

No Contact       Minimal Contact       Substantial Contact

7. How effective was the fellow's contribution this summer?

Not Very Effective       Generally Satisfactory       Excellent Progress

8. Please comment on the fellow's cooperativeness, diligence and interest:

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9. In what way(s) do you believe that the summer program has increased the fellow's competence and research potential?

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10. How has your interaction with the fellow been of benefit to your technical skills and progress?

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11. Would it be of value if the fellow were able to bring a graduate research student to join in the technical program?

Not Very       Somewhat       Very       No Opinion

12. By the end of the second summer's fellowship, will the research results be written up as a manuscript for submission to a major archival journal?

Yes       Probably       Doubtful

If yes, to which journal(s) will the manuscript be sent?

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13. In addition, or alternately, will the fellow and/or yourself present a paper at a major technical society meeting or symposium in your field?

Yes       Probably       Doubtful

A. Name of the technical society or symposium?

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B. Do the proceedings of the above meeting constitute a recognized publication?

Yes       No

14. As you know, the Summer Faculty Fellowship Program is intended as an overall enrichment experience. The main emphasis is on participation in some phase of aerospace research of interest to NASA-Ames/Dryden. Also included are activities such as seminars, workshops and interaction with Stanford faculty.

Please indicate the nature of any overall benefit to NASA drawing from your collaboration with the fellow and your overall assessment of the program, with specific recommendations for improvement.

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15. **For Colleague's of First Year Fellows:**

*(Your evaluation of the faculty member's performance is our key criterion for awarding a fellowship to continue their research for a second summer. Your candid comments will be appreciated and will be held in confidence).*

- A. What influenced your selection of this particular faculty fellow (check all that apply):

Previous knowledge of his/her work or reputation.

Conversations (phone or in-person) with the fellow.

Review of the fellow's application file.

Other (please specify) \_\_\_\_\_

- B. Are you interested in serving as the research advisor/NASA colleague for this fellow again next summer?       Yes       No

If not, why? \_\_\_\_\_

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16. **For Colleague's of Second Year Fellows:**

- A. Did you maintain personal contact with the fellow during the past academic year?  Yes  No

If yes, to what extent? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

- B. Are there plans for future follow-up work with this fellow at his home institution via grant, contract, or other arrangement?

Yes  No

If yes, what is anticipated? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

- C. Are you interested in serving as the research advisor/NASA colleague of a new fellow in the future?  Yes  No

If not, why? \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Thank you for your input.

Signature: \_\_\_\_\_

Date: \_\_\_\_\_

7/15/98

**1998 NASA-ASEE-Stanford  
Summer Faculty Fellowship Program**

**Ames Research Center Fellows' Calendar**

<b>Monday, June 8th Orientation</b>	Fellows' orientation meeting from 9:30 - 11:00 a.m. Bldg. 233, Room 172.
<b>Special Seminars</b>	Seminars on New Science and Technology in the Aerospace Age; Terman Auditorium, Stanford University; Thursdays, 8:00 p.m.; June 25, July 2, 9, 16, 23, 30, and August 6. These lectures are open to the public and family members are welcome to attend. The guest speaker schedule is enclosed
	Seminars on Current Research in the Aerospace Sciences; NASA Ames Research Center; Tuesdays, 12:00 noon - 1:00 p.m.; June 23 and July 7, 14, and 21. The June 23 seminar will be held in the building 245 auditorium, all others will be held in Bldg. 233, Rm. 172. NASA colleagues and co-workers are welcome to attend. The guest speaker schedule is enclosed. Note: On July 28, the Stanford Linear Accelerator Tour will be held in lieu of the seminar.
<b>Friday, June 12th Ames Research Center Tour</b>	All fellows will meet in the Ames Cafeteria at 8:30 a.m. (Bldg. N-235 at the intersection of Durand and King Rd.). Map is enclosed. A final schedule will be available the morning of the tour.

We will visit the following facilities:

8:30 - 9:00 a.m.	Overview Ames Cafeteria, Galileo Room <i>Speaker?</i>
9:00 - 9:20	Group Photo (near the 12-Foot Wind Tunnel)
9:30 - 10:20	Cray Supercomputing Facility (Bldg. 258) <i>Gina Morello</i>
10:30 - 11:20	T-NASA Navigation System (Bldg. 262) <i>Mike Atkins</i>
11:30 - 11:45	Centrifuge Facility (Bldg. 221A) <i>Mal Cohen</i>
11:55 - 12:10	Bone Loss in Space Exercise & Osteoporosis (Bldg. 239) <i>Robert Whalen</i>
12:15 - 1:00	Lunch (Ames Cafeteria)
1:05 - 2:00	Unitary Modernization Project (Across from Bldg. 226) <i>Dan Button</i>
2:25 - 2:50	Vertical Motion Simulation (Bldg. 243) <i>Leighton Quon</i>

<b>Sun. - Tues., June 28-30 Asilomar Workshop Retreat</b>	Registration from 3:00 - 4:15 P.M. on Sunday, June 28. Asilomar Conference Center, 800 Asilomar Blvd., Pacific Grove. Schedule and map enclosed.
<b>Thursday, July 4th</b>	Independence Day Holiday
<b>Friday, July 10th</b>	Research review titles are due for all ASEE fellows.
<b>Friday, July 17th 3:30 p.m.</b>	<b>Social:</b> Tour of The Hoover Institute Archives & Pot-Luck Picnic. The Archives of the Hoover Institution of War, Revolution, and Peace document the political, social and economic changes that has shaped the world of the 20th century. We will tour the archives where some of the "treasures" will be on display, and learn about the history of the Institution and the life of its founder, Herbert Hoover. We'll meet in the lobby of the Hoover Tower at 3:30 p.m. Afterwards, we will have a pot-luck picnic near the Stanford oval. Join us for one or both. Family members are welcome.
<b>Tuesday, July 28th 1:00 - 3:00 p.m.</b>	<b>Stanford Linear Accelerator Center Tour.</b> The Stanford Linear Accelerator Center (SLAC) is one of a handful of laboratories worldwide that stands at the forefront of research inthe study of the basic constituents of matter and of the forces that act between them. The SLAC program centers around experimental and theoretical research in elementary particle physics using electron beams and a broad program of research in atomic and solid state physics, chemistry, biology and medicine using synchrotron radiation. Operated by Stanford University and the Department of Energy, the principal research instrument used is a two-mile-long linear electron accelerator, or linac. Family members are welcome. Meet at the Ames visitor center (the shuttle model) to arrange car pools at 12:30 that day.
<b>Monday, August 10th Tuesday, August 11th Research Reviews</b>	All ASEE fellows are expected to attend the research reviews. Review sessions will be held in the second floor auditorium of building 245. A request for the title of your presentation is enclosed. A schedule will be distributed by the end of July. Colleagues and fellow NASA researchers are encouraged to attend.
<b>Monday, August 10th</b>	End of summer luncheon. Details to follow.
<b>Friday, August 14th *</b>	<p><b>Final Research Summary Report Due.</b> (Three pages maximum, including references and figures). See example enclosed.</p> <p><b>ASEE Evaluation of Program Due.</b> Form to be completed by fellows (will be mailed to you in late July).</p> <p><b>Colleague's Evaluation of Performance &amp; Program Due.</b> (The form will be mailed to you in late July along with your ASEE evaluation. Please give it to your colleague for him/her to complete and return to Marilyn, MS 241-3).</p>

\* Note: In order to receive a final summer stipend payment the research summary report and both evaluations must be turned in.

**NASA ASEE SUMMER FACULTY FELLOWSHIP PROGRAM  
1998 APPLICANTS**

<b>NAME</b>	<b>POSITION &amp; INSTITUTION</b>	<b>SPECIAL FIELD OF INTEREST AND RESEARCH</b>
Abdelmessih, Amanie N (Female)	Assoc. Prof., Mechanical Engineering, Saint Martin's College. Lacey, WA	Thermal sciences, theoretical and experimental heat transfer, active cooling of sensors and cold electronics, chemical engineering, materials science. Ph.D. , Chemical Engineering (SFFP, Marshall 1991 & 92; Argonne Nat. Lab 1996) <b>(DRYDEN)</b>
Compadre, Cesar M. (Hispanic)	Assoc. Prof., Biopharmaceutical Sciences, University of Arkansas for Medical Sciences. Little Rock, AR.	Computer simulation of GI physiology; 3-D simulation model of the human gastrointestinal tract, prediction of effects of microgravity; GI physiological, pharmacological and pathological functions on earth; computational chemistry. Ph.D., Medicinal Chemistry and Pharmacognosy
Friedman, Jane E. (Female)	Assoc. Prof., Mathematics & Computer Science, University of San Diego. San Diego, CA.	Combinatorics, numbers theory, combinational conjectures, theoretical and practical computer science, mathematics education, information technology. Ph.D., Mathematics.
Garcia, Oswaldo (Hispanic)	Professor, Meteorology, San Francisco State University. San Francisco, CA.	Detection of polar stratospheric clouds in AVHRR imagery, remote sensing applications to the study of the atmosphere, development of algorithms to detect polar stratospheric clouds (PSCs). Ph.D., Atmospheric Sciences
Henry, Joel E.	Asst. Prof., Computer & Information Sciences, East Tennessee State University. Johnson City, TN.	Software engineering, process and quality; user interface; software reliability and productivity. Ph.D., Computer Science.
Herrick, Paul E.	Asst. Prof., Aviation Technology, University of Alaska at Anchorage. Anchorage, AK.	Wind tunnel aerodynamics, aerodynamic decelerators, flight operations, flight data acquisition systems, aerospace education: curriculum support, teacher enhancement, critical thinking and problem solving. M.S., Aviation Technology. <b>(DRYDEN)</b>

Herwitz, Stanley A.	Professor, Biogeography & Earth Science, Clark University. Worcester, MA.	Airborne digital camera remote sensing of canopy tree population and georeferenced crown growth, tropical rainforest canopy dynamics: 3-D modeling, Ph.D., Biogeography & Geomorphology.
Kesten, Philip R.	Assoc. Prof., Physics, Santa Clara University. Santa Clara, CA.	High energy particle physics, observational astronomy, studies of the properties of amorphous (cometary) ice, IR spectroscopic analysis of radiation -processed ice residues. Ph.D., Physics.
Korienek, Gene G.	Dr. (Ph.D.), Faculty, Exercise and Sport Science Oregon State University. Corvallis, OR	Artificial intelligence, cognitive science, autonomous vehicles/limbs, biological robotic control, biologically inspired robotic movement. Ph.D., Movement Science
Ladkany, Samaan, G.	Professor, Civil & Environmental Engineering, University of Nevada, Las Vegas. Las Vegas, NV.	Finite element, propeller fan dynamics, rotorcraft aero-mechanical behavior, rotor fluid/structures coupling. (Joint proposal with Prof. Culbreth to work with Wm. Warmbrodt). Ph.D., Structural Mechanics.
Lambert, Michael A.	Asst. Prof., Mechanical and Aerospace Engineering San Jose State University. San Jose, CA	Thermal contact conductance; metalic, anodic, ceramic, and diamond coating deposition and characterization as thermal protection material; electronics and avionics cooling and environmental testing. Ph.D., Mechanical Engineering (SFFP, Johnson 1997)
Liang, Michael T.C. (Asian)	Asst. Prof., Kinesiology, Bowling Green State University. Bowling Green, OH.	Bone loading and metabolism, lean muscle mass, temperature regulation, muscular strength and stability, geriatric postural stability (sway patterns) and locomotor gaits. Ph.D., Exercise Physiology.
Lowery, Mary Sue (Female)	Assoc. Prof., Biology, University of San Diego. San Diego, CA.	Muscle biochemistry and physiology; effects of microgravity on the regulation of muscle protein synthesis or protein degradation; fish muscle physiology: fish fast-twitch muscle as a response to either exercise or starvation. Ph.D., Marine Biology.

MacDougall, Preston J.	Asst. Prof., Chemistry Middle Tennessee State University. Murfreesboro, TN	Nanotechnology, device modeling, molecular modeling and materials simulation, computational chemistry, theory of electronic materials, slow electron dynamics of molecules. Ph.D., Chemistry
Maddren, Jesse	Asst. Prof., Mechanical & Aerospace Engineering, San Jose State University. San Jose, CA.	Experimental heat transfer; thermal protection system materials; thermophysical properties of rigid, fibrous insulation materials. Ph.D., Mechanical Engineering.
Mena-Werth, José L. (Hispanic)	Asst. Prof., Physics and Physical Sciences University of Nebraska at Kearney. Kearney, NE	Solar and stellar variability, extra-solar planet detections, stellar atmospheres using visual & ultraviolet observations. Ph.D., Astronomy (SFFP, Ames 1994 & 95)
Metzger, Ellen P. (Female)	Professor, Geology, San Jose State University. San Jose, CA.	Geochemistry, petrology, mineralogy, earth science education, Mars-related projects, remote sensing, global systems. Ph.D., Geology.
Nemes, Richard M.	Assoc. Prof., Computer Science, Pace University. New York, NY.	Software engineering for ultra-reliability, information management, self-organizing data structures/data bases, continuously-available high volume data bases. Ph.D., Computer Science.
Pizzarello, Sandra (Female)	Faculty Research Associate, Chemistry and Biochemistry Arizona State University. Tempe, AZ	Cosmochemistry and exobiology, organic compounds in carbonaceous chondrite meteorites, nature of matter in the interstellar medium, origin of the universe and life on earth. Ph.D., Biological Sciences
Pronchick, Stephen W.	Assoc. Prof., Engineering and Technology California Maritime Academy. Vallejo, CA	Turbulence and transition, modeling and experimental validation, aerodynamics facilities and operation, fluid and flight mechanics. Ph.D., Mechanical Engineering
Rafkin, Scot C.R.	Asst. Prof., Earth Systems Science & Policy Inst. California State University - Monterey Bay Seaside, CA	Mesoscale modeling (of Martian phenomena), cloud resolving simulations, atmospheric chemistry and dynamics, regional modeling on Mars, surface-atmosphere interactions. Ph.D., Atmospheric Science

Seitz, Jeffery C.	Asst. Prof., Geological Sciences California State University - Hayward. Hayward, CA	Science education, interdisciplinary science education, pre-service teacher ed., geochemistry, petrology, (ALERT), Ph.D., Geological Sciences
Senger, Steven O.	Professor, Computer Science & Mathematics, University of Wisconsin, LaCrosse. LaCrosse, WI.	Scientific visualization, computational science, automata theory and complexity theory, logic programming & PROLOG, interactive and volumetric imaging. Ph.D., Mathematics.
Shahnasser, Hamid	Professor, Electrical Engineering San Francisco State University. San Francisco, CA	Modeling and simulation and traffic studies of present and future applications in multimedia, network modeling and simulation/performance evaluation, distributed systems and multimedia applications. Ph.D., Electrical and Computer Engineering
Sheehan, Daniel P.	Assoc. Prof., Physics, University of San Diego. San Diego, CA.	Planet formation, star formation, planetary science, origin of solar system, plasma physics, experimental fluid dynamics, turbulent protoplanetary nebular disks in the context of a nonlinear fluid process: Rhines' inverse turbulent cascade. Ph.D., Physics.
Sheldon, Frederick T.	Asst. Prof., Computer Science, University of Colorado. Colorado Springs, CO.	Software/systems engineering: research to develop and validate methods and tools for the creation of safe and corre software (mathematical modeling, ultra reliable and F.T. systems), specification modeling and validation. Ph.D., Computer Science.
Stone, Bradley M.	Assoc. Prof., Chemistry San Jose State University. San Jose, CA	Laser spectroscopy of large aromatic molecules of astrophysical interest, molecular physics, laser spectroscopy, astrochemistry. Ph.D., Chemical Physics (SFFP, Ames 1995-96)
Taub, Frieda B. (Female)	Professor, School of Fisheries, University of Washington. Seattle, WA.	Aquatic ecology, water ecology, closed ecological systems, fishery ecology, CELSS, gravitational biology, bioregenerative systems for space habitats, ecotoxicology. Ph.D., Zoology (DOE at Battelle N.W., Richland, WA, 1989)

Thompson, Joel B.	Asst. Prof., Marine Science Eckerd College. St. Petersburg, FL	Role of bacteria into forming minerals and possible links to life and fossils on Mars, geochemical signatures of the bacterial role in forming sediments and rocks, exobiology, geomicrobiology, biogeochemistry. Ph.D., Geology
Tucker, Tommy N.	Technical Writing Instructor, English Isothermal Community College. Spindale, NC	Technical communications, problem-solving team structures, critical thinking and problem solving in young inventors, design of technical education curricula. M.S., English (DRYDEN)
Ward, Robin A. (Female)	Asst. Prof., Mathematics, California Polytechnic State University, San Luis Obispo. San Luis Obispo, CA	Math education, K-12 teaching tools, graphing calculator activities using the World Wide Web. Ph.D., Mathematics Education (DRYDEN)